in northern New York, we can be fairly certain of the climatic similarities of the two regions. More than that, a type of virgin forest growth may serve as a better indication of the climate of a particular locality than meteorological records covering a short number of years. A forest which has grown on the same ground for many generations is the result not of any exceptional climatic cycle, but is the product of the average climatic conditions that have prevailed in that region for a long time. It expresses not only the result of one single climatic factor, but is the product of all the climatic and physical factors together. Similarly, the use of the natural forest types for determining the potential capacity of the land occupied by them for different purposes, is becoming more and more appreciated. When the climatic characteristics of a certain type of forest, for instance, those of Engelmann spruce in the Rocky Mountains, is thoroughly established, the potential capacity of the land occupied by it for agriculture, grazing, or other purposes is also largely determined.

Observations of the effect of climate upon forest growth naturally brought out facts with regard to the effect of forests upon climate, soil, and other physical factors and led to the development of a special branch of meteorology, known as forest meteorology, in which the foresters have taken a prominent part. While there are some phases in forest meteorology which still allow room for disagreement, some relationships established by foresters are widely accepted. One of these is the effect which forests have upon local climate, especially that of the area they occupy and of contiguous areas. Every farmer who plants a windbreak knows and takes advantage of this influence. Another relation is that between the forest and the circulation of water on and in the ground, a relation which plays such an important part in the regimen of streams. Still a third one, as yet beyond the possibility of absolute proof, is the effect of forests in level countries, in the path of prevailing winds, upon the humidity and temperature of far-distant regions lying in their lee. * * *

WHY SOME WINTERS ARE WARM AND OTHERS COLD IN THE EASTERN UNITED STATES.

By W. J. HUMPHREYS, Professor of Meteorological Physics.

[Dated Weather Bureau, Washington, Feb. 1, 1915.]

INTRODUCTION.

As every one knows, no two winters are exactly alike. Even a short memory will convince one living in the eastern United States that here some winters are much colder than the average while others are exceptionally mild. Of course, many other places experience similar differences in the severity, or, if one prefers, geniality of their seasons, and to each there necessarily belongs an interesting study of how these differences occur and why. In the present paper, however, only exceptional winters in the eastern United States will be considered.

LIST OF ABNORMAL WINTERS.

An examination of the climatological records shows that beginning with December, 1880, the earliest date for which we have sufficient and convenient data for the present study, the eastern United States has had a number both of exceptionally mild and of exceedingly cold winter months. The more pronounced of these are listed in Table 1, in which the numbers give, roughly, each the average temperature departure for the month in question, over the eastern United States, from the corresponding normal.

TABLE 1.—*Excessive monthly temperature departures in the eastern United States.*

Winters.	December.	January.	February.	March.
	°F.	°F.	°F.	°F.
1880-81	−4	−4		−3
1881-82	5	4	5	
1883-84			6	
1884-85			−6	−6
1885-86		−4		
1886-87	−5			
1887-88				−4
1889-90	7	9	9	
1890-91			6	
1891-92	6			
1892-93		−8		
1893-94		4		
1894-95			−7	
1897-98				5
1900-1901			−5	
1903-04	−5	−5	−5	
1904-05	−4		−7	
1908-09			4	
1911-12	5	−5		
1912-13	4	9		5

PREPONDERANCE OF LOCAL OVER GENERAL CAUSES.

If we omit isolated months and consider only entire winter seasons, it will appear that usually the temperature departure of the eastern United States has been of the same sign as that of the whole world, which in turn seems to depend upon the combined influence of sun spots and volcanic dust (1). This general agreement shown in Table 2, it should be remembered, is between the annual temperature departure of the world as a whole and the winter temperature departure of only the eastern United States. Therefore, agreements and disagreements in their signs, since the periods are not the same and since the local seasonal departure often is from 10 to 20 fold that of the world-wide annual departure, probably have but little meaning. Nevertheless, if the number of cases were sufficiently large there probably would be rather more instances where the signs of the departures were the same than where they were different; hence, though the period covered is too short satisfactorily to test even this point, it seems only fair to give the comparison table for whatever, if anything, it may be worth.

TABLE 2.—*Comparison of seasonal local (winter, eastern United States) and annual world-wide temperature departures.*

Date.	Winter, eastern United States.	Year, world.	Comparison.
1880-81	Cold	Warm	Disagreement.
1881-82	Warm	do	Agreement.
1884-85	Cold	Cold	Do.
1889-90	Warm	Warm	Do.
1903-04	Cold	Cold	Do.
1912-13	Warm	Insufficient data.	(?).

On its face this table indicates decidedly more agreements than disagreements, but, as already stated, the local winter temperature departures under consideration are so many times greater than the world-wide annual departures that the causes of the latter, though, of course, having their influence, clearly can not be the chief cause of the former. Neither do the former, pertaining to but a single season and covering only a small part of the globe, often determine the character or sign of the latter, though necessarily they always affect its magnitude.

Presumably, indeed, there are a number of unequal and constantly varying factors that contribute, each its share, to the final results under discussion, namely, the establishment of abnormal winter temperatures, whether high or low, in the eastern United States.

RELATION OF PRESSURE DISTRIBUTION OVER THE NORTH ATLANTIC TO THE AVERAGE WINTER TEMPERATURE OVER THE EASTERN UNITED STATES.

Of the several causes, however, that control the winter temperatures of the eastern United States, *the magnitude and distribution of the barometric pressure over the north Atlantic Ocean*, through their influence on the direction and velocity of the winds and on the course, intensity, and nature of the moving storms, certainly are among the most important—in many cases probably the most important. In so general a form, however, this statement contains nothing new. At most it only delimits an important example of the climatological influence of the positions and intensities of what Teisserenc de Bort has aptly called "great centers of action," an influence first discussed at length, especially with reference to European winters, by Hoffmeyer (2) and later in greater detail and with wider application by Teisserenc de Bort (3). The partial dependence of American temperatures upon Atlantic pressures has also long been recognized by officials of the United States Weather Bureau (4).

This particular temperature-pressure relation, therefore, is well known to meteorologists, and constantly kept in mind by the American forecasters. Nevertheless its importance, both to the science of meteorology and to the art of forecasting, is sufficiently great to justify the threefold purpose of the present paper, namely:

(*a*) To bring together for study and convenient comparison the average pressure maps of the north Atlantic for all winter months of abnormal temperature departures in the eastern United States, since and including December, 1880, the earliest date for which such maps are conveniently available.

(*b*) To describe what seems to be a logical reason *why* the pressure distribution and its changes, especially in the important region of the Bermudas, should be what they are.

(*c*) To designate certain particular data which, if they should prove available, might logically be used as the basis for such general long-range (week, month, season) forecasts for the eastern United States as "Severe," "Normal," "Mild."

To facilitate as far as possible the study of the relation of the winter temperatures of the eastern United States to the distribution of barometric pressure over the north Atlantic Ocean, the temperature departure and pressure charts (monthly averages in each case) are given [1] for all the months listed in Table 1. Charts 1–17 (92–108), arranged chronologically, pertain to the cold months. Similarly, charts 18–33 (109–124), also arranged chronologically, pertain to the warm months. The temperature charts are taken from Bulletin "U" of the United States Weather Bureau (to and including the winter of 1908–9) and from the MONTHLY WEATHER REVIEW. The pressure charts from December, 1880, to February, 1905, inclusive, are copied from the best, though not generally available, weather maps of the North Atlantic (5), published jointly by the Meteorological Institute of Denmark and the German "Seewarte." The later pressure charts, those pertaining to 1909, 1911, 1912, and 1913, years for which the Danish-German charts have not yet been published, were prepared for use in this study by Frederick A. Young, of the Climatological Division of the United States Weather Bureau, to whom I wish to express my thanks and appreciation for the excellent manner in which he has carried to completion so long and so tedious a piece of work. The pressure normals were also supplied by the United States Weather Bureau, using all the best available data down to about the end of 1912.

Even a cursory examination of these pressure charts, will show that, while no two are exactly alike, those that pertain to the months of abnormally low temperatures in the eastern United States, the "cold" charts, as I shall call them, are characterized in general by an easterly displacement or intensification of the "Azores high," and the absence of any distinct "high" in the neighborhood of the Bermudas; by a strong "low" in the general region of the Newfoundland banks; or, occasionally, by both conditions.

On the other hand, the "warm" charts show a marked tendency to westward shifting of the "Azores high," and even to the development and greater or less persistence of an independent "high" in the region of the Bermudas.

The most conspicuous difference, then, between the "warm" and the "cold" type of charts appears to be in the pressure distribution along the "belt of highs." I shall, therefore, consider each type separately in its relation to this belt, but the individual charts will not be described.

Cold type.—When there is only one absolute high, or only one peak on this pressure ridge, at or east of its normal position, the temperature of the eastern United States is likely, in the wintertime, to be unusually low. (See charts 1–17.) The reason for this is obvious: That portion of the circulation about this "high" that involves warm air or southerly winds, the circulation to the west of the center of the area of high pressure, is all completed on the ocean itself. None of the warm southerly winds involved in this circulation crosses the Atlantic coast onto or over the American continent. Hence the normal westerly and northwesterly winter winds have an entirely free passage to and even far out onto the Atlantic, and in this way the whole of the eastern United States is given at such times a distinctly continental or cold (being winter) climate. The same general type of wind movement across the continent and out onto the ocean, with, during the winter, accompanying low temperatures, is permitted, or, rather, forced by a quasi stationary and well developed "low" in the neighborhood of the Newfoundland banks, and that, too, in a measure, independent of the pressure distribution along the high-pressure belt. (See chart W. J. H. 11.)

In short, that pressure distribution, whatever it may be, that causes the winds persistently to blow across the eastern United States from the interior of the continent out onto the ocean, gives to it a continental climate, and, therefore, in the winter, abnormally low temperatures. The wind roses and the isobars of the chart for January, 1912 (W. J. H., 17), illustrate the above explanations.

Warm type.—Whenever the Atlantic section of the high-pressure belt develops, and for a considerable time

[1] These charts, designated W. J. H. 1–W. J. H. 35, will be found at the end of this issue of the Review, numbered also consecutively from XLII–92 to XLII–126.

maintains, a Bermuda "high," whether independent of or in conjunction with an Azores "high;" and whenever what might be regarded as the permanent Azores "high" exists alone, but strongly displaced toward the west, the anticyclonic circulation thus established is quite likely to extend from warmer portions of the Atlantic Ocean out onto and over the eastern United States. Thus the normal storms are shunted farther north and this part of the country is given a distinctly marine climate, and, therefore, in the winter time, an abnormally high temperature. A good illustration of this action is shown by the wind roses and isobars for January, 1913 (W. J. H. 32).

It seems, then, that some winters are warm in the eastern United States and others cold because this part of the world has sometimes a more or less marine climate and at others a distinct continental climate. And the chief factors in determining this, in turn, in making the climate in question marine or continental, in giving on- or off-shore winds, are the positions and intensities of the Atlantic anticyclones, or the locations and magnitudes of the pressure peaks along the north Atlantic high-pressure ridge.

But this answer leads to still other and, if it is substantially correct, very important questions, namely: What causes these peaks or absolute "highs"? Why does the Bermuda "high" so persist of some winters and so seldom form, or when formed so quickly disappear, of others?

The first of these questions is answerable through a consideration of the "belt of highs," and this in turn suggests the probable answer to the second question.

"Belt of highs."—As is well known, the winds between the latitudes 30° N. and 30° S., roughly, blow more or less directly from east to west. Similarly the winds of higher latitudes in each hemisphere generally cross the meridians from west to east. Now, the equatorial bulge of the earth is just such that an object at rest on the surface of the ocean has no tendency to move either north or south, or, for that matter, in any other horizontal direction. In short, the ocean surface is a gravitational equipotential surface. If the earth should rotate more rapidly its equipotential surface (substantially its ocean surface) would become more bulged; if less rapidly, less bulged. Hence, an object moving from west to east finds the present surface insufficiently bulged to permit of its equilibrium and it therefore tends to climb up toward the equator. Similarly, an object moving in the opposite direction, or from east to west, is also out of equilibrium; it finds the earth too much bulged and consequently tends to slide down toward the nearest pole. From this it obviously follows that the winds from the west toward the east—that is, in general, the winds of higher latitudes than about 30° north and south—tend to climb up toward the equator, while the winds from the east toward the west, or those between approximately these latitudes, tend to slide down toward the nearest pole. Hence along the boundaries between the eastward and the westward winds, or along, roughly, the latitudes of 30° N. and 30° S., there necessarily are belts of dynamically produced and dynamically sustained high pressure.

The equatorial deflection of an eastward-moving object and the polar deflection of a westward-moving one are indeed but special cases of the well-known general law, readily found by a little analysis, that an object moving over the surface of the earth is always, whatever its horizontal direction, deflected to the right in the Northern Hemisphere and to the left in the Southern.

The numerical value of this force f, acting on the mass m, whose horizontal velocity is u at the latitude ϕ, is given by the equation

$$f = 2m\omega u \sin\phi$$

in which ω is the angular velocity of the earth.[2]

"Permanent highs."—The northern high-pressure ridge has two distinct peaks and the southern ridge three, which together are known as the permanent highs. Two are on the Pacific Ocean, one just west of southern California, the other near the coast of Chile; two on the Atlantic Ocean, near Morocco and southern Africa, respectively; and one on the Indian Ocean, about half way between southern Africa and Australia. In every case they occur where, or, rather, for reasons that will not be gone into here, just west of where the surface water, and therefore the air over it, has a lower temperature than has that either to the west or to the east. That is, they occur in every case where and only where cold ocean currents cross the belts of high pressure, and obviously result from the superposition of a thermal contraction upon the existing mechanical squeeze (6).

It is well known from sounding balloon records that anything like a long-continued change in the surface temperature is accompanied by only a little less temperature change of the atmosphere up to great altitudes—probably as far as the air has any appreciable density. Hence, above oceanic areas also, especially if, as in the cases under discussion, these be anticyclonic centers and therefore regions of sluggish air movement, we should expect the temperature to follow, in general, that of the surface water below. Hence, a decrease of 1°C. in the surface temperature should increase the density of the air above by roughly one part in 300 to 350, and the barometric pressure by from 2 mm. to 2.5 mm. But in the regions of the permanent highs, according to Buchan's charts, the temperature of the surface air ranges anywhere from 1°C. to 3°C., roughly, below that on the same latitude either east or west. Hence, we might expect at these places barometric peaks extending approximately from 2 mm. to 6 mm. above the average height of the general pressure ridge, and this indeed is the order of their normal heights.

The Bermuda "high."—As we have seen, all five of the so-called permanent "highs" are on the belts of high pressure and result from the local addition of a thermal contraction to an existing extensive belt of mechanical compression. Hence, the possibility suggests itself that the often-formed and at times quasi-permanent Bermuda "high," since it, too, is located on one of the barometric ridges, may also owe its origin to the crossing of this ridge by a belt of water whose surface temperature is lower than that either to the east or to the west; in short, that it, too, like each of the permanent "highs,"

[2] Lest the terms of this equation should be misunderstood, it may be worth while to explain them.

If the units involved are the centimeter, the gram, and the second, then:

f = dynes. A dyne is that force which gives to a gram of matter, entirely free to move, an acceleration of 1 centimeter per second per second. That is, during each second of continuous application it increases the velocity of the gram, in the direction of application, by 1 centimeter per second. A simple conception of the dyne is this: It is the weight of a gram divided by the numerical value of the local acceleration of gravity, or, approximately, it is the one 980th part of the weight of a gram.

m = number of grams in question, moving as a single unit.

ω = angular velocity of the earth's rotation measured in radians per second. Numerically,

$$= \frac{2\pi}{\text{seconds per siderial day}} = \frac{2\pi}{86,146}$$

u = velocity in terms of centimeters per second.

$\sin\phi$ = natural sine of the angle of latitude.

may be caused by a *minimum surface temperature* (giving maximum air density) along the barometric ridge on which it is situated.

Indeed, the idea that the Bermuda "high," especially when at all persistent, may be produced in the manner suggested seems to be strongly supported by charts 34 and 35 (125 and 126) that give, respectively, the February and May surface temperature of the North Atlantic (**7**).

The Bermuda cold area.—According to the Deutsche Seewarte charts, in crossing the Atlantic along the "belt of highs," a region of minimum surface temperature commonly is met, except during midsummer, in the general neighborhood of the Bermudas. What this low surface temperature is due to is not certain, but it seems to be connected with and dependent upon the strength and temperature of the Labrador current. If so—that is, if the surface temperature of the Bermuda cold area is lowest when the amount of "cold" brought by the Labrador current is greatest and least pronounced when this supply of cold is at a minimum—it clearly follows that the Bermuda "high" and, therefore, the temperature of the eastern United States must depend in part upon the Labrador current; that is, during the winter, the stronger this current the more intense the Bermuda "high," and the greater the excess of the average temperature of the eastern United States above its normal temperature. Hence, during the winter, a strong and persistent Labrador current would seem, through the creation and maintenance of a well-defined Bermuda "high," to give the eastern United States a marine climate and thereby to hold its average temperature well above its normal value. On the other hand, a relatively feeble winter Labrador current would presage the absence of Bermuda "highs," the prevalence of westerly or northwesterly winds, and, therefore, a continental climate and abnormally low temperatures over all the eastern United States.

Hence daily information in regard to the surface temperatures in the region of the Bermuda "high," in addition to the usual meteorological data for the same region, might be of decided help to the American forecaster. Hence, also, if the surface temperature near the Bermudas be controlled by the Labrador current, it is obvious that a proper study and gaging of this current—the measurement of its cross section, velocity, and temperature—if made at the right times and often enough repeated, might furnish information that occasionally would justify a tentative forecast of the type of coming winter weather in the eastern United States weeks or even months in advance.

These latter measurements, those pertaining to the Labrador current, clearly would be difficult, at present, perhaps, entirely impracticable, to make. This fact, however, does not forbid a discussion of their potential meteorological importance.

Of course, if the above is the actual chain of cause and effect, it clearly does not end with the Labrador current, but until this important point is cleared up it would be premature, however obvious the next link, to attempt to follow it further.

CONCLUSION.

The general facts and conclusions of this paper are:

1. Some winters in the eastern United States are unusually mild and others exceptionally cold.

2. During mild winters this part of the country temporarily has a marine climate, during cold ones a continental climate.

3. The type of winter climate, marine or continental, in this section is largely determined by the presence or absence of the Bermuda "high."

4. Persistence, during winter, of the Bermuda "high" gives to the eastern United States a marine and, therefore, for it, an unusually mild climate. Continued absence of this "high," during winter, allows a continental climate and, therefore, exceptionally low temperatures, to extend quite to the Atlantic coast.

5. The cause of the Bermuda "high" seems to be a cold-water surface, a minimum surface temperature, along the belt of highs.

6. This low surface temperature in the region of the Bermudas may depend upon the temperature and strength of the Labrador current.

7. A knowledge of the surface temperature in the region of the Bermuda "high" probably would be of value to the American forecaster.

8. If the Bermuda "high" is, as it seems to be, dependent upon the Labrador current, then proper gaging of this current should give some indication (during winter at least and probably other seasons as well) a fortnight or a month ahead of the type of coming weather in the eastern United States.

9. A persistent strong Labrador current would seem to indicate a subsequent (fortnight or longer) development of a more or less equally persistent Bermuda "high," and through it the prevalence during winter of relatively warm weather throughout the eastern United States. On the other hand a long continued, weak Labrador current would indicate subsequent absence of Bermuda "highs" and the prevalence over the eastern United States of unusually low temperatures.

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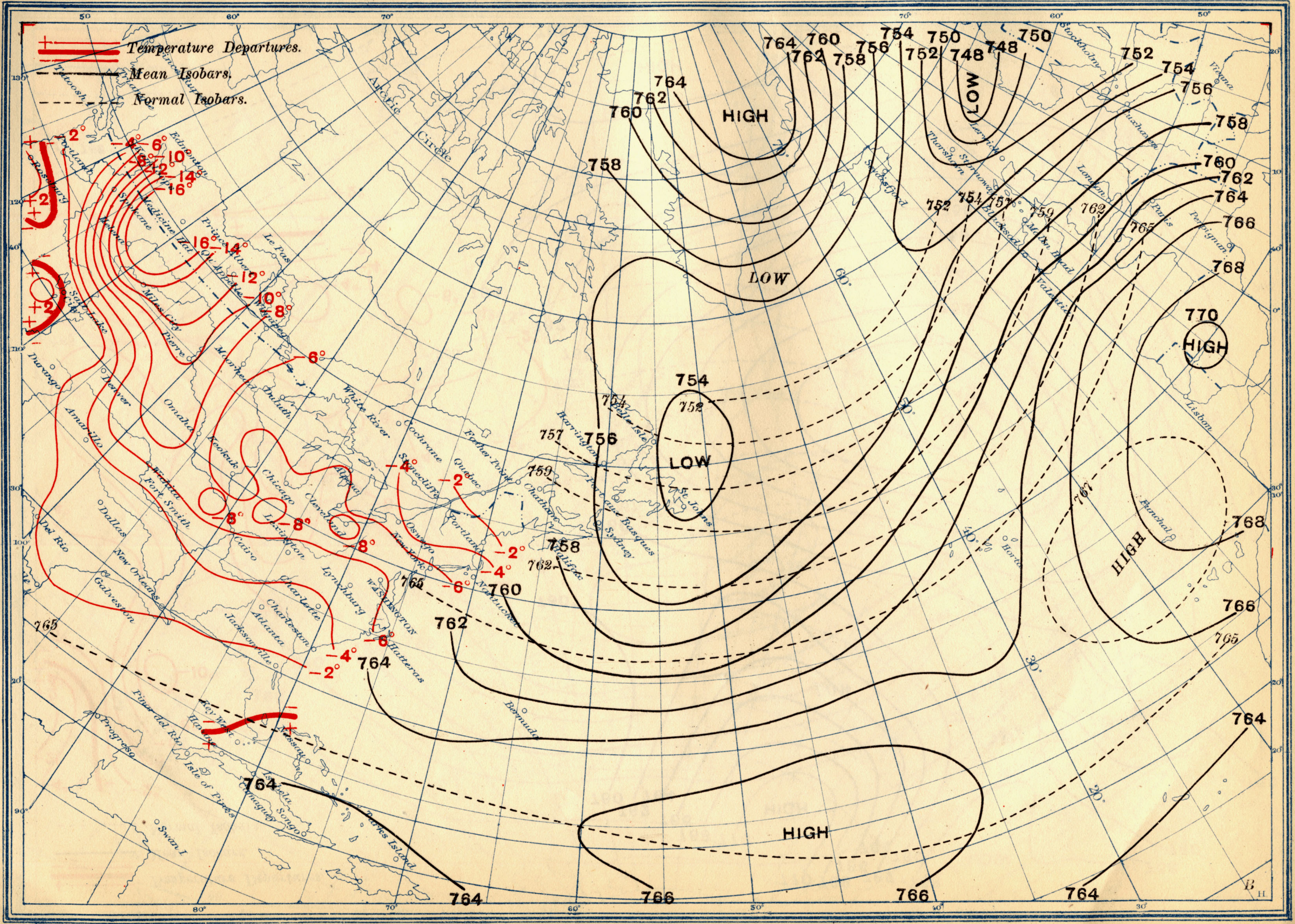
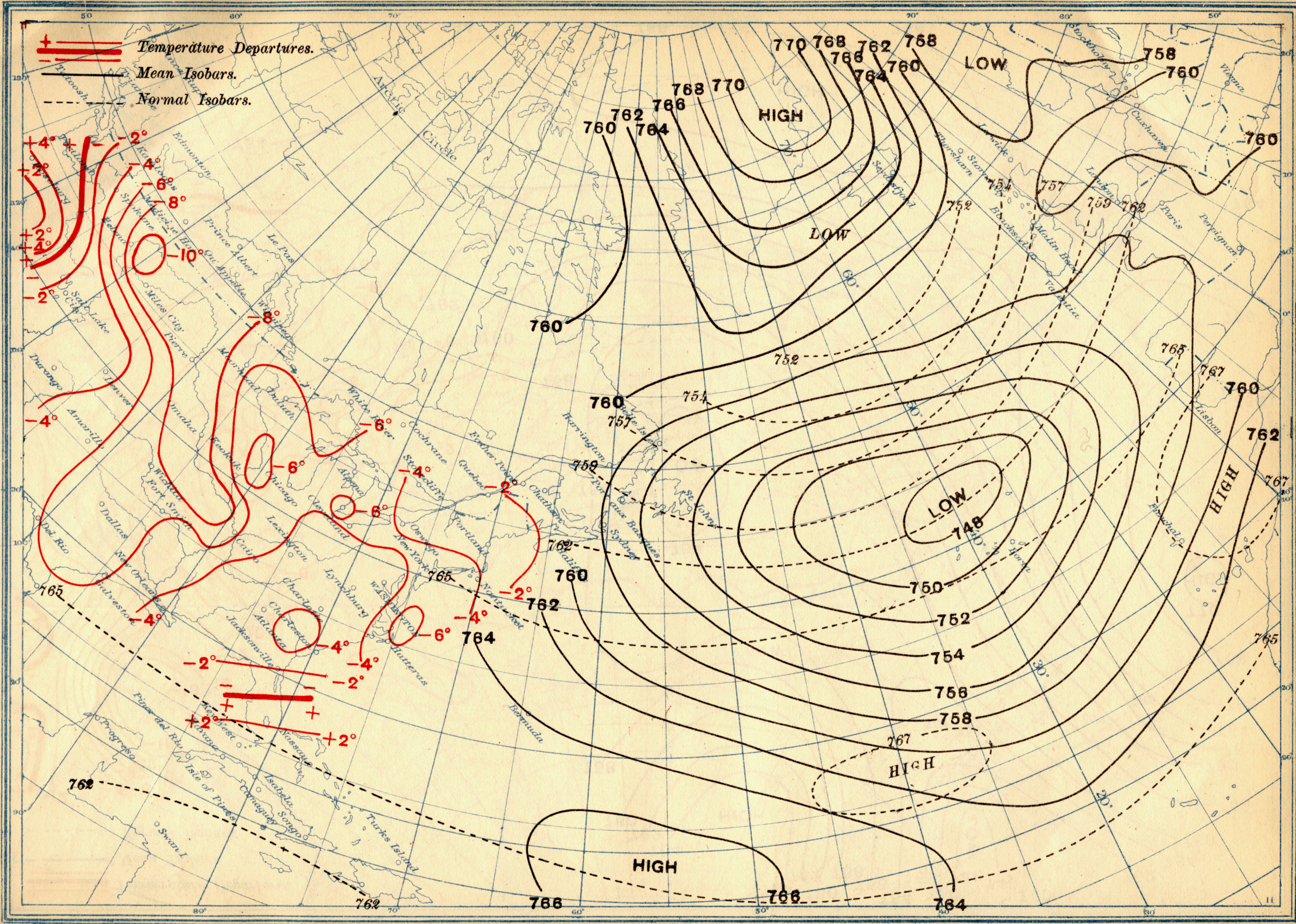
INTERNATIONAL SIMULTANEOUS OBSERVATIONS.

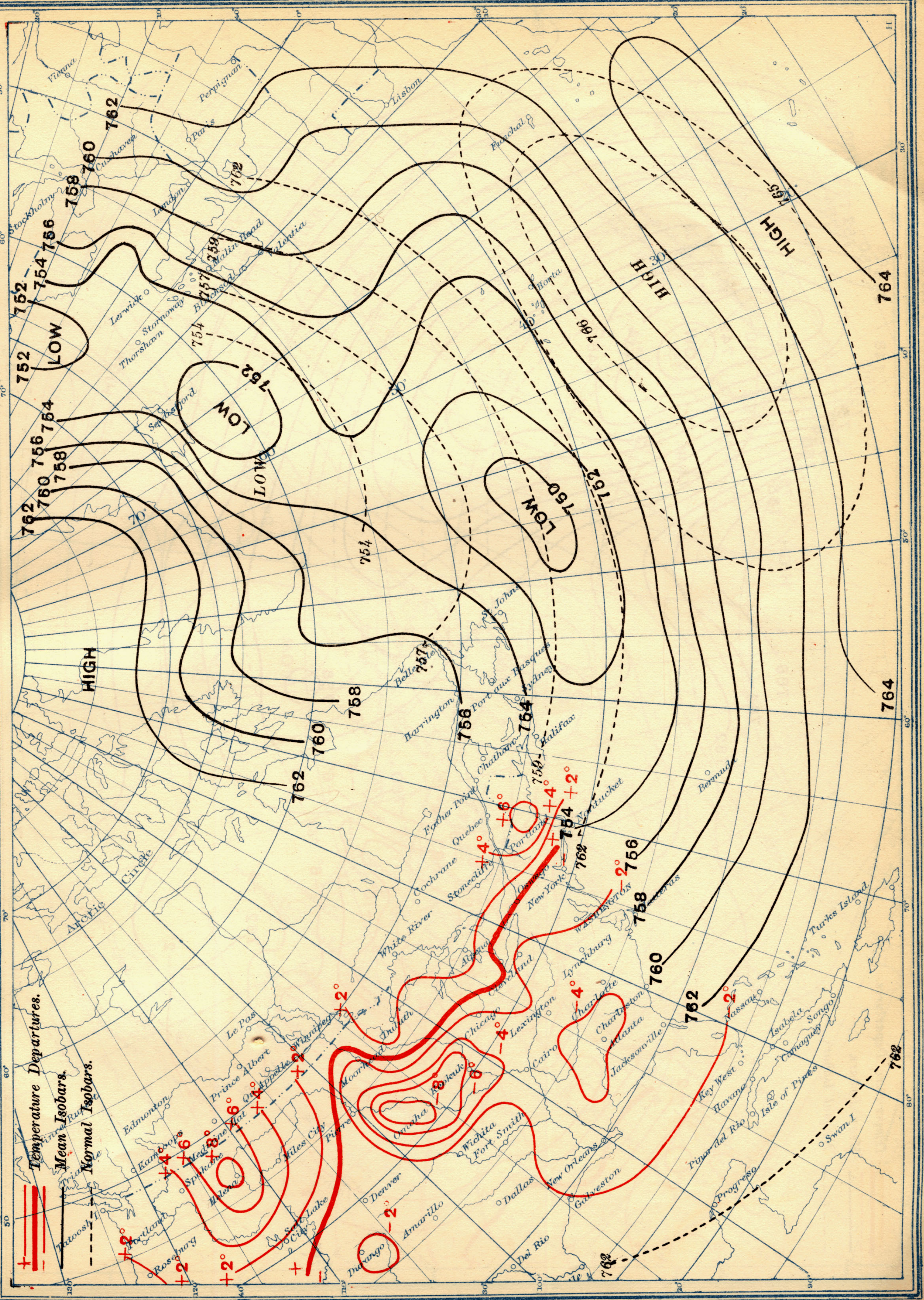
As early as 1871, in the development of the meteorological work of the United States Signal Service (now the Weather Bureau) it became evident that our storms on land were affected by so large a portion of the atmosphere that they could not be satisfactorily studied on the thrice-daily weather maps of the United States as then in use. The same difficulty holds good with regard to the weather map of the United States now in use. In June, 1871, at my request the official forecaster, Gen. Albert J. Myer, as chief of the bureau, sent to captains and owners of vessels circulars and forms requesting tri-daily simultaneous meteorological observations at sea, especially along our coasts. This marine work of the Signal Service grew steadily, even rapidly, until 1887, when all its official work

W. J. H. 1.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, December, 1880.



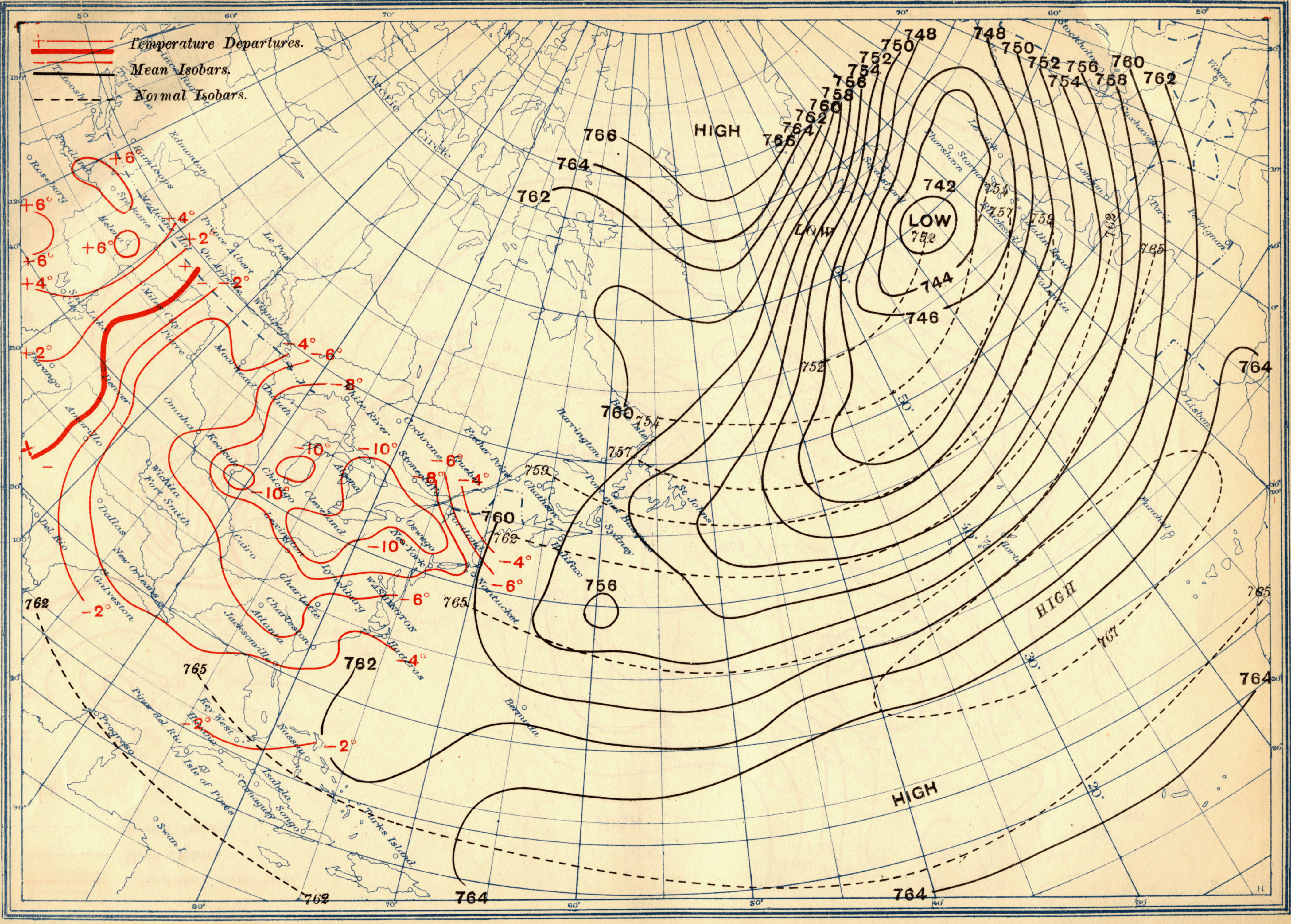
W. J. H. 2.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, January, 1881.



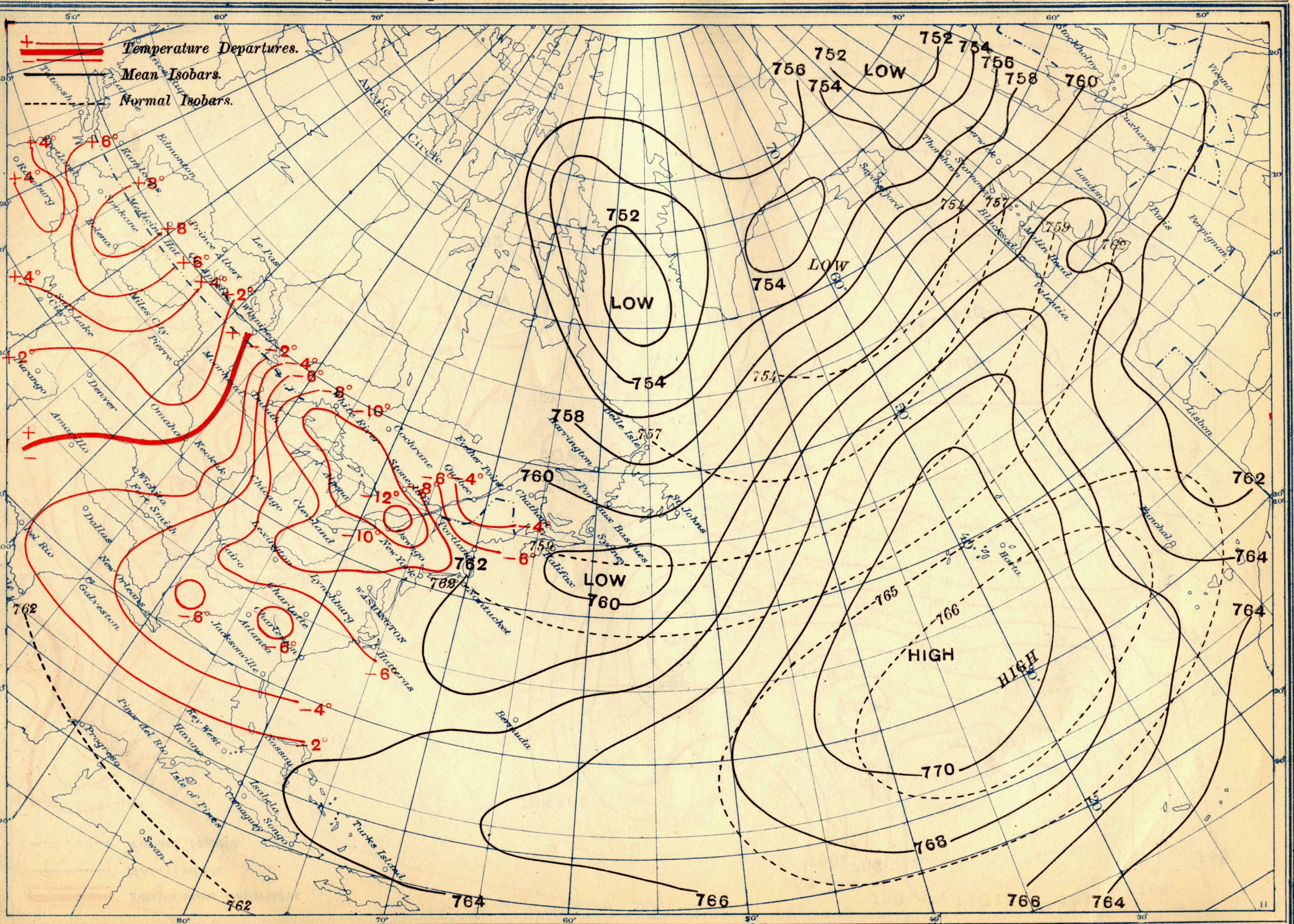


W. J. H. 3.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, March, 1881.

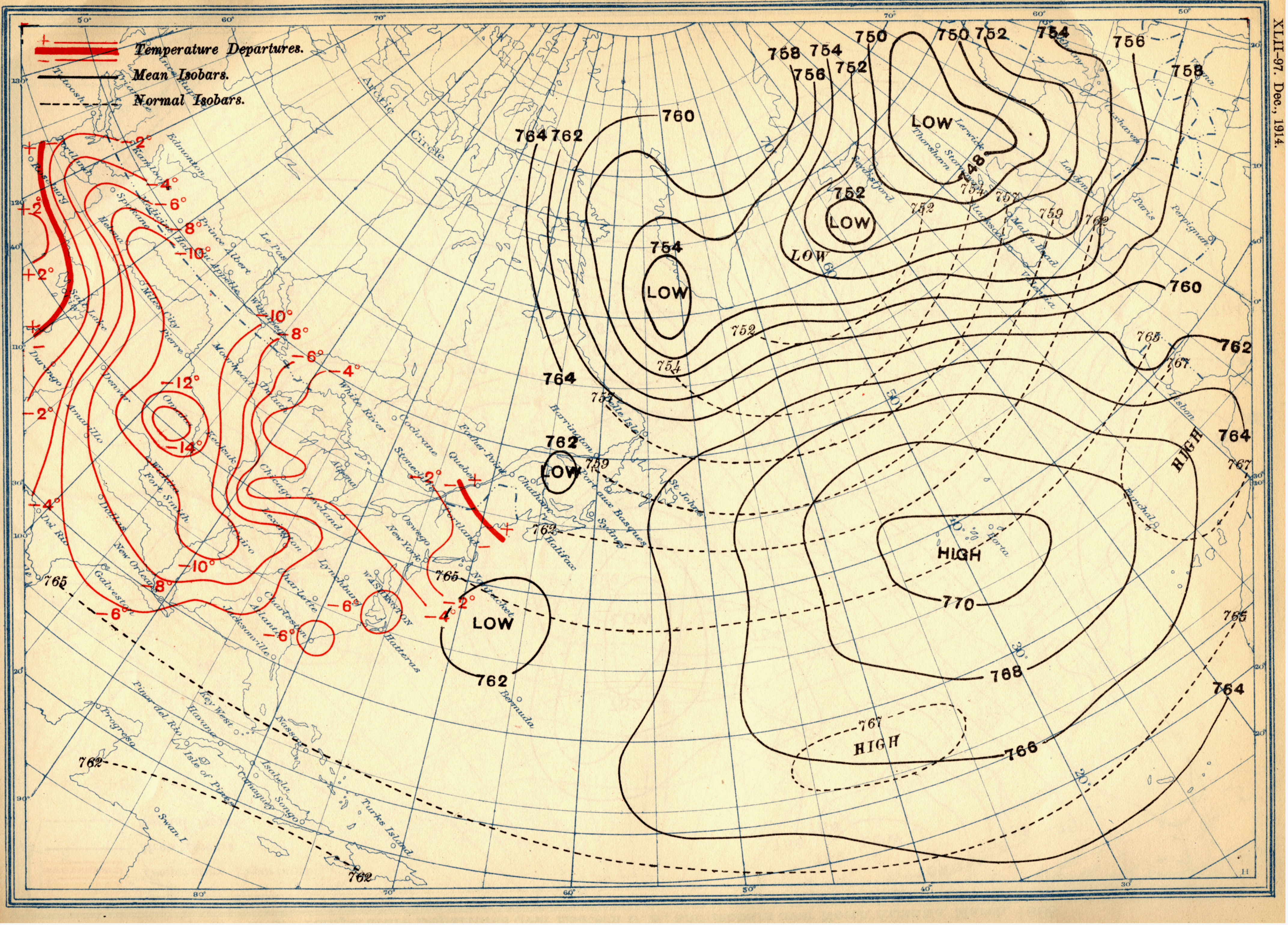
W. J. H. 4.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, February, 1885.



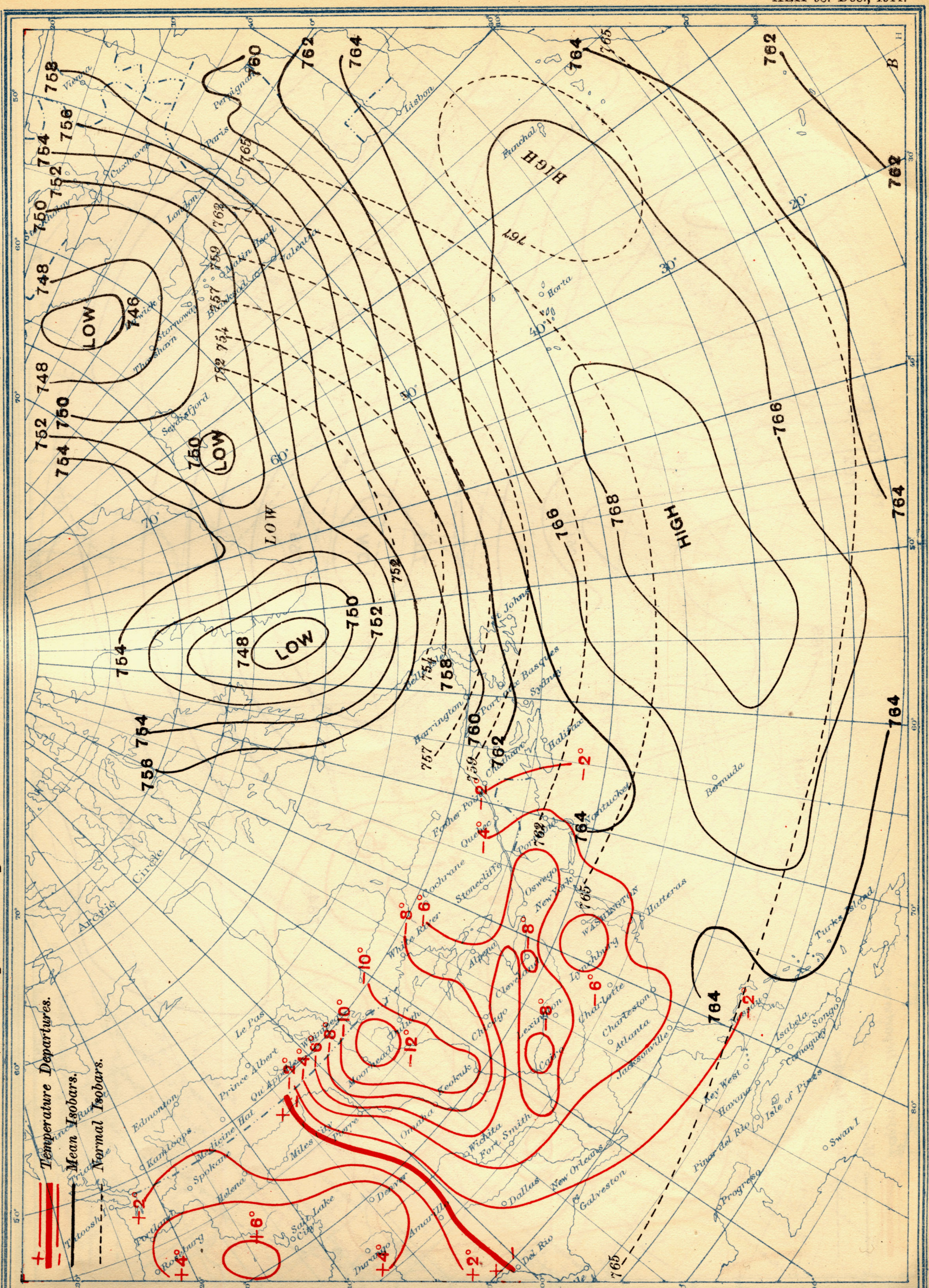
W. J. H. 5.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, March, 1885.



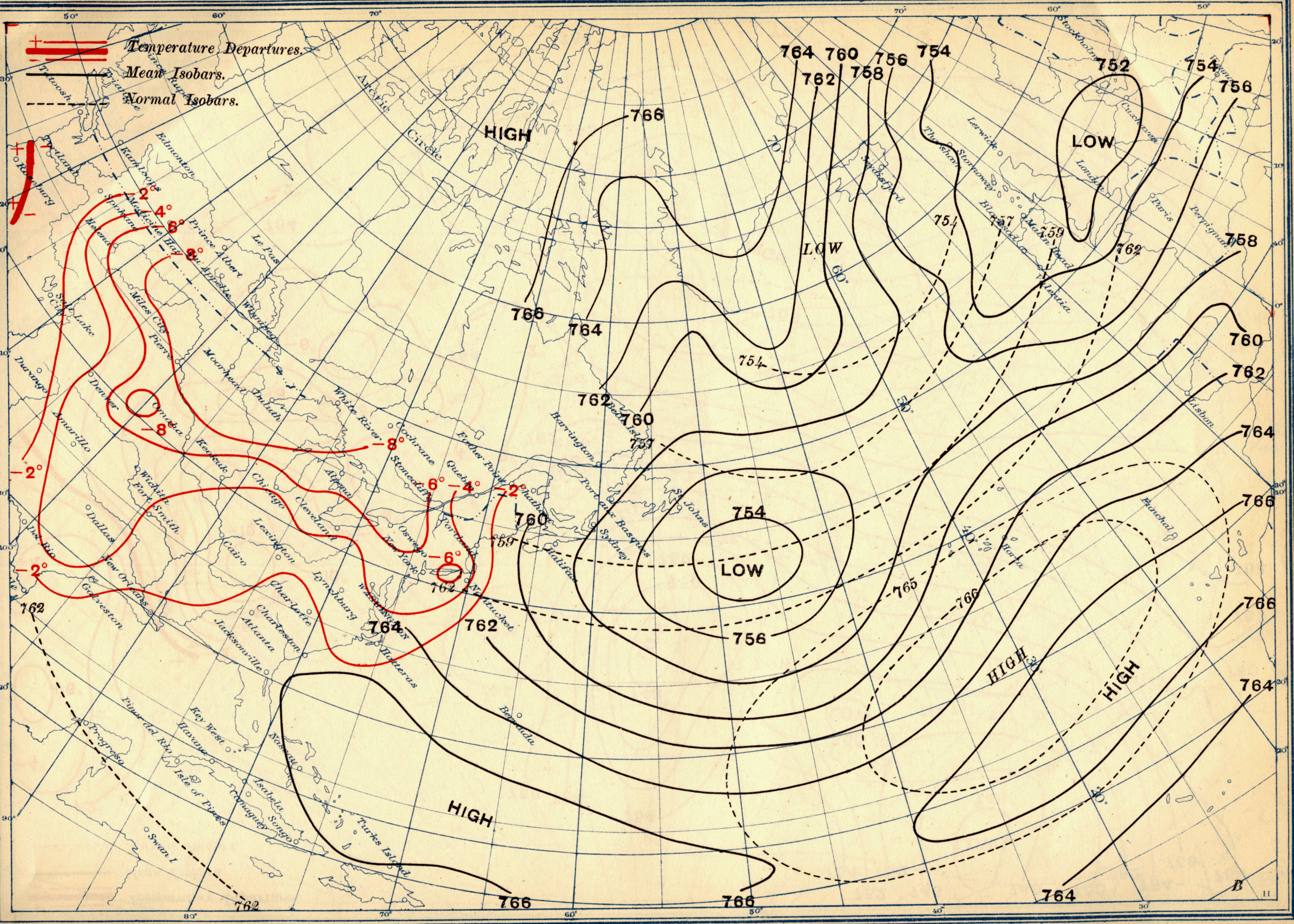
W. J. H. 6.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, January, 1886.



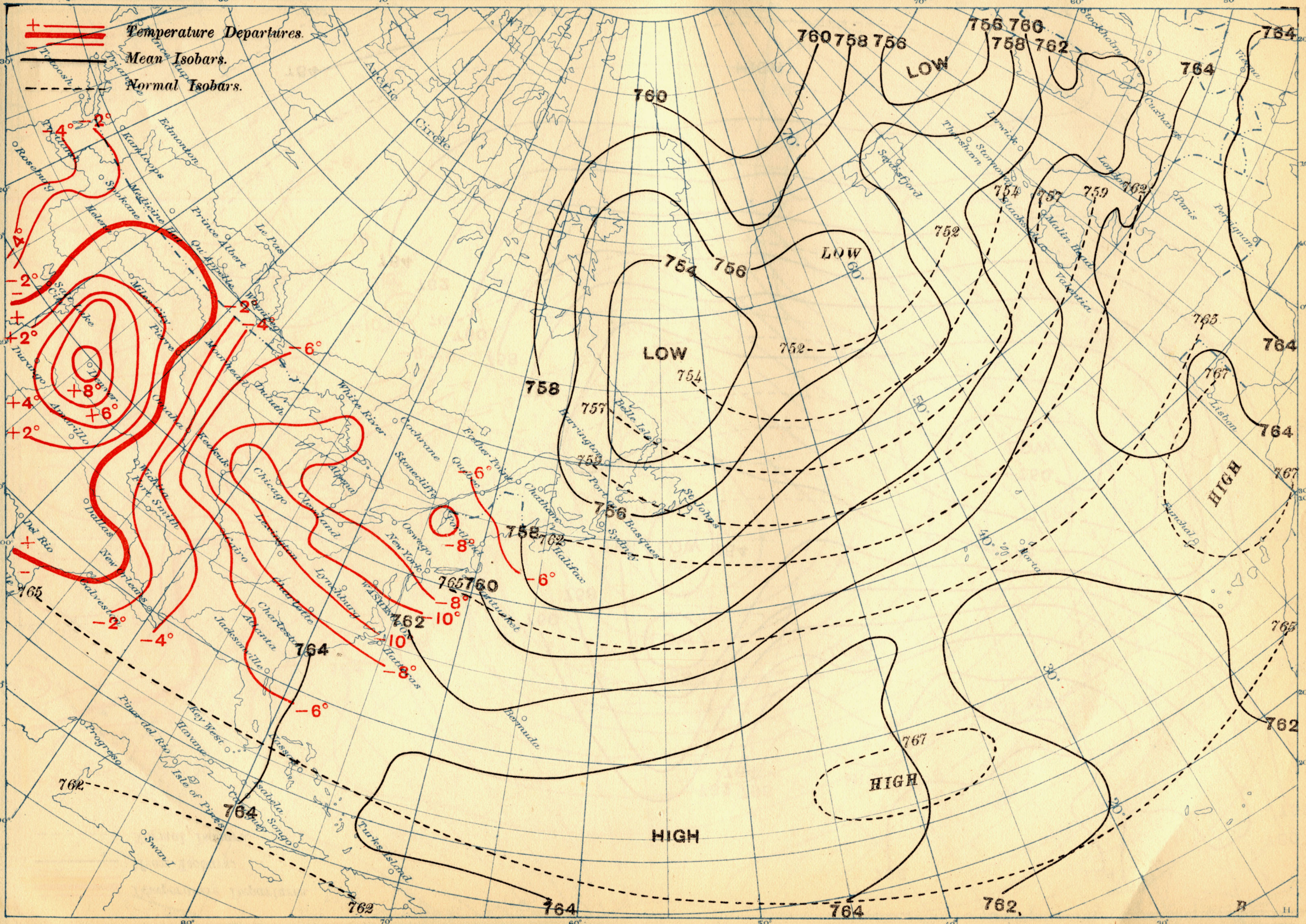
W. J. H. 7.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, December, 1886.



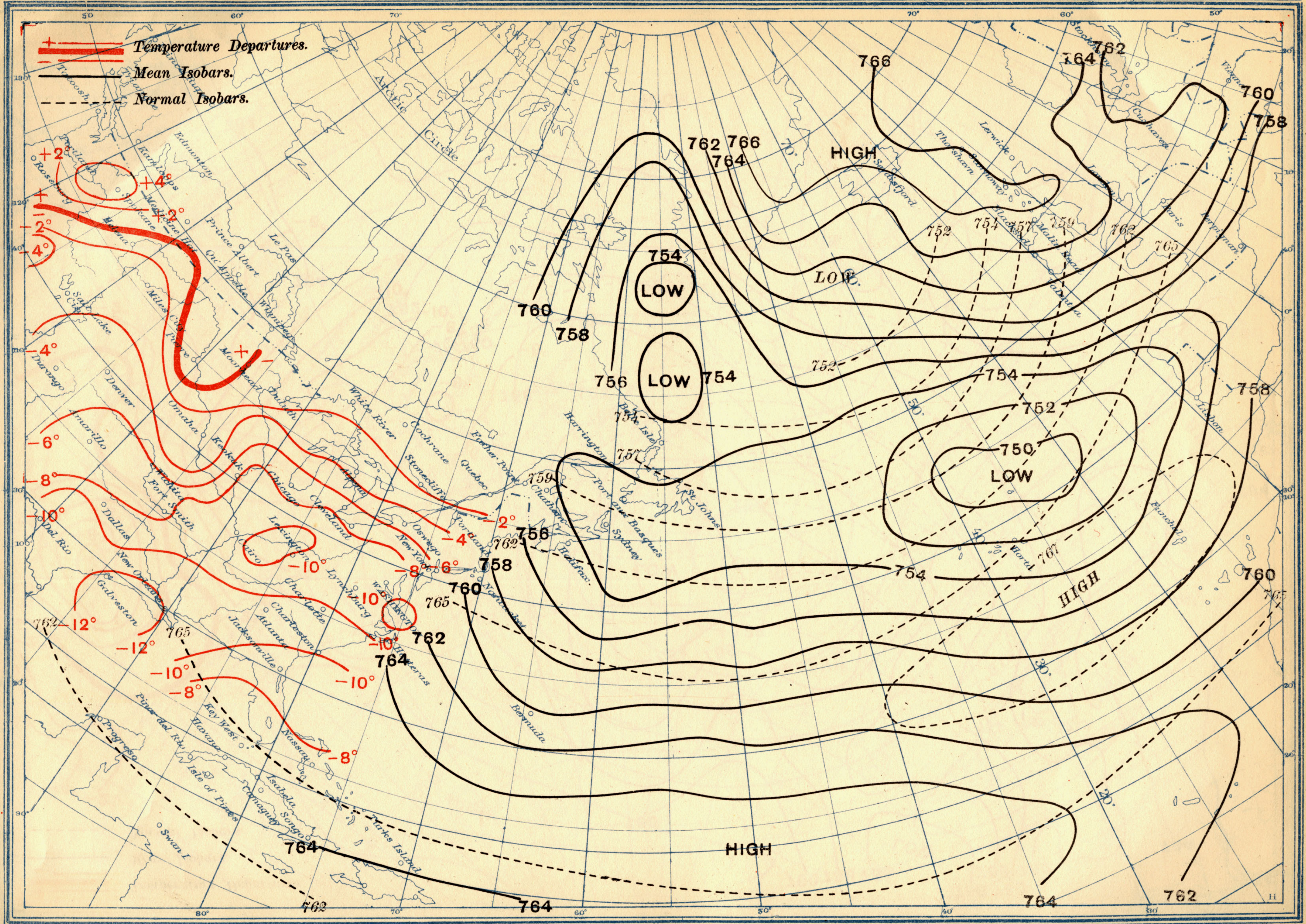
W. J. H. 8.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, March, 1888.



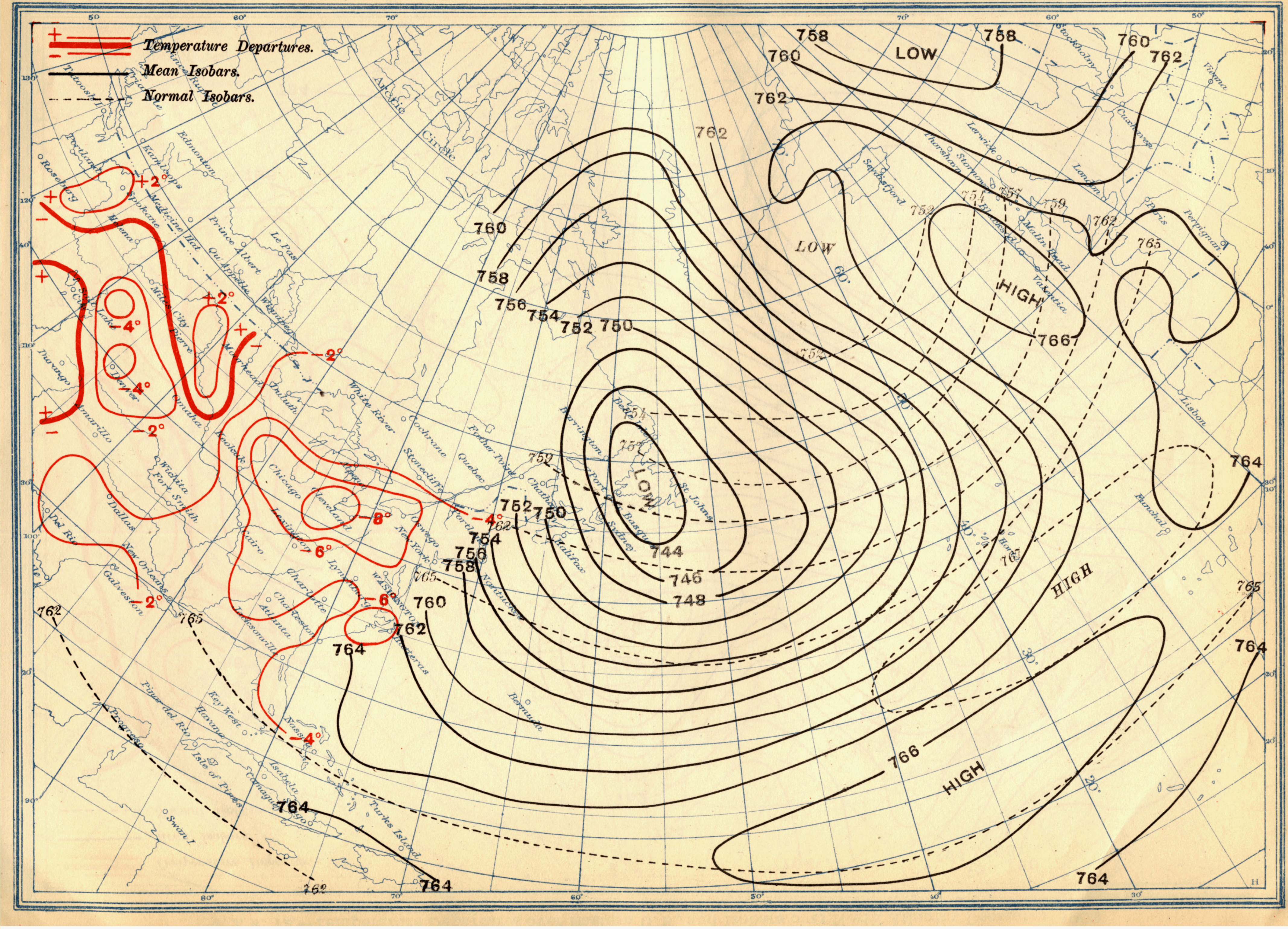
W. J. H. 9.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, January, 1893



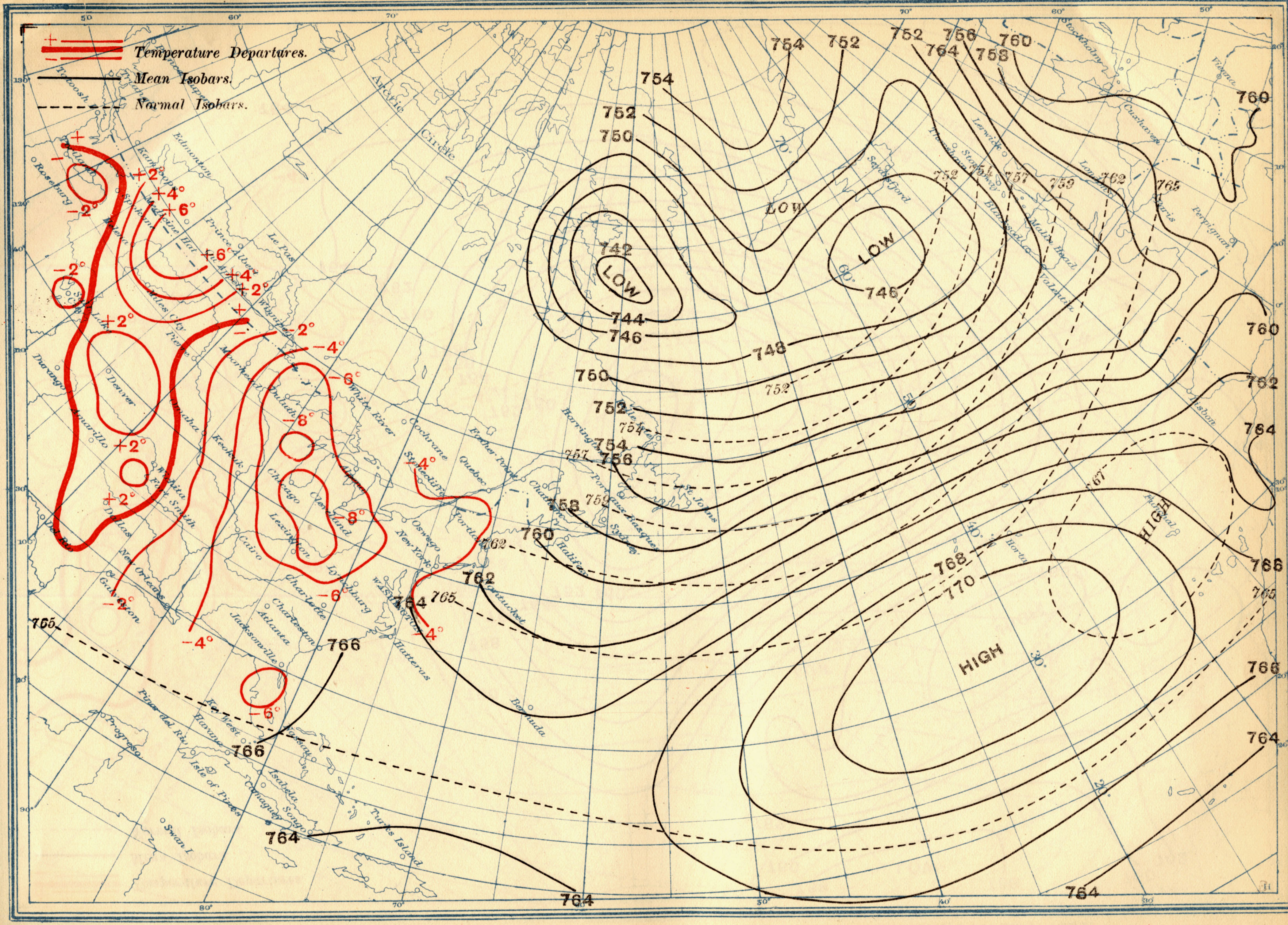
W. J. H. 10.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, February, 1895.



W. J. H. 11.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, February, 1901.

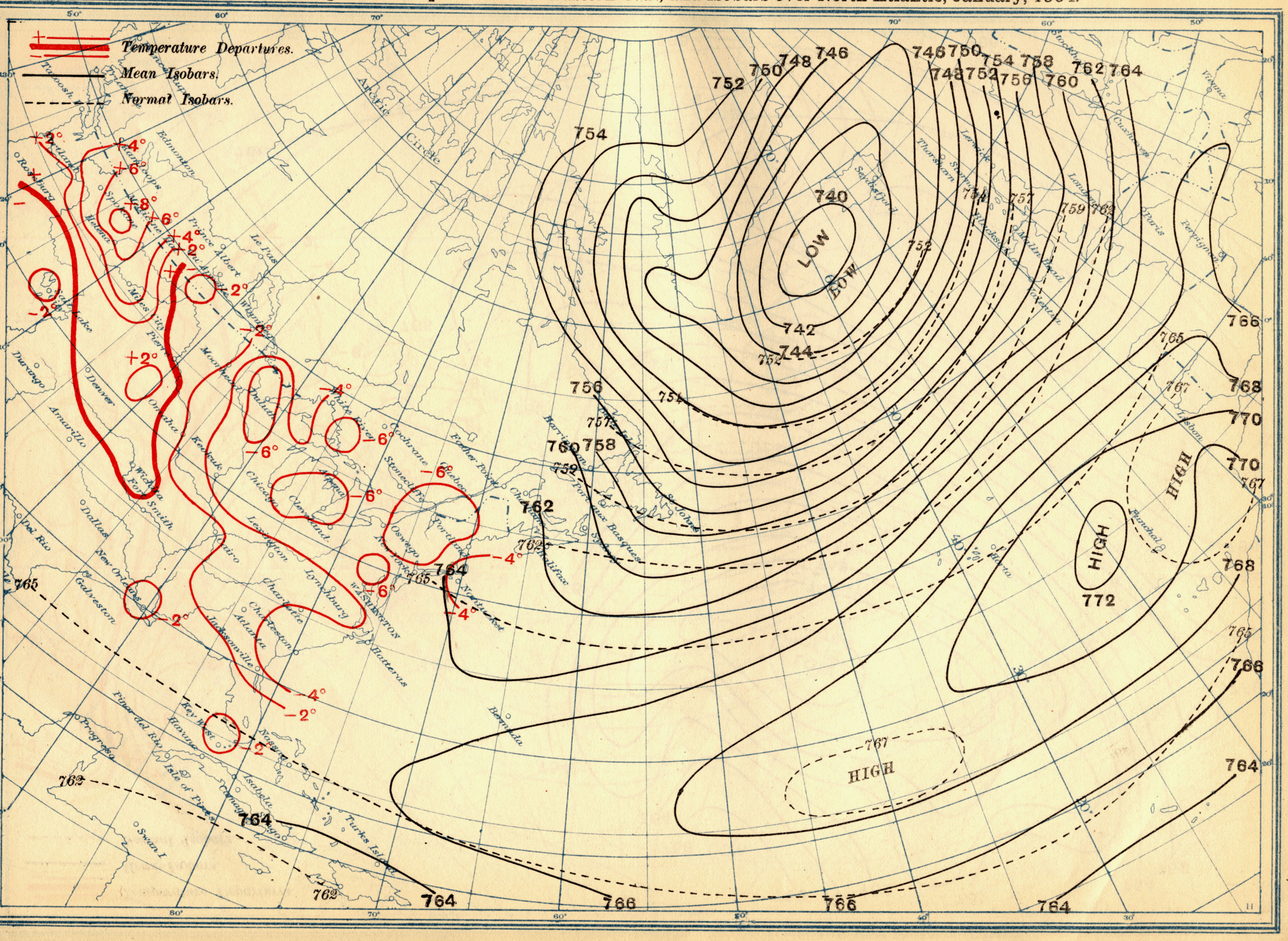


W. J. H. 12.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, December, 1903.

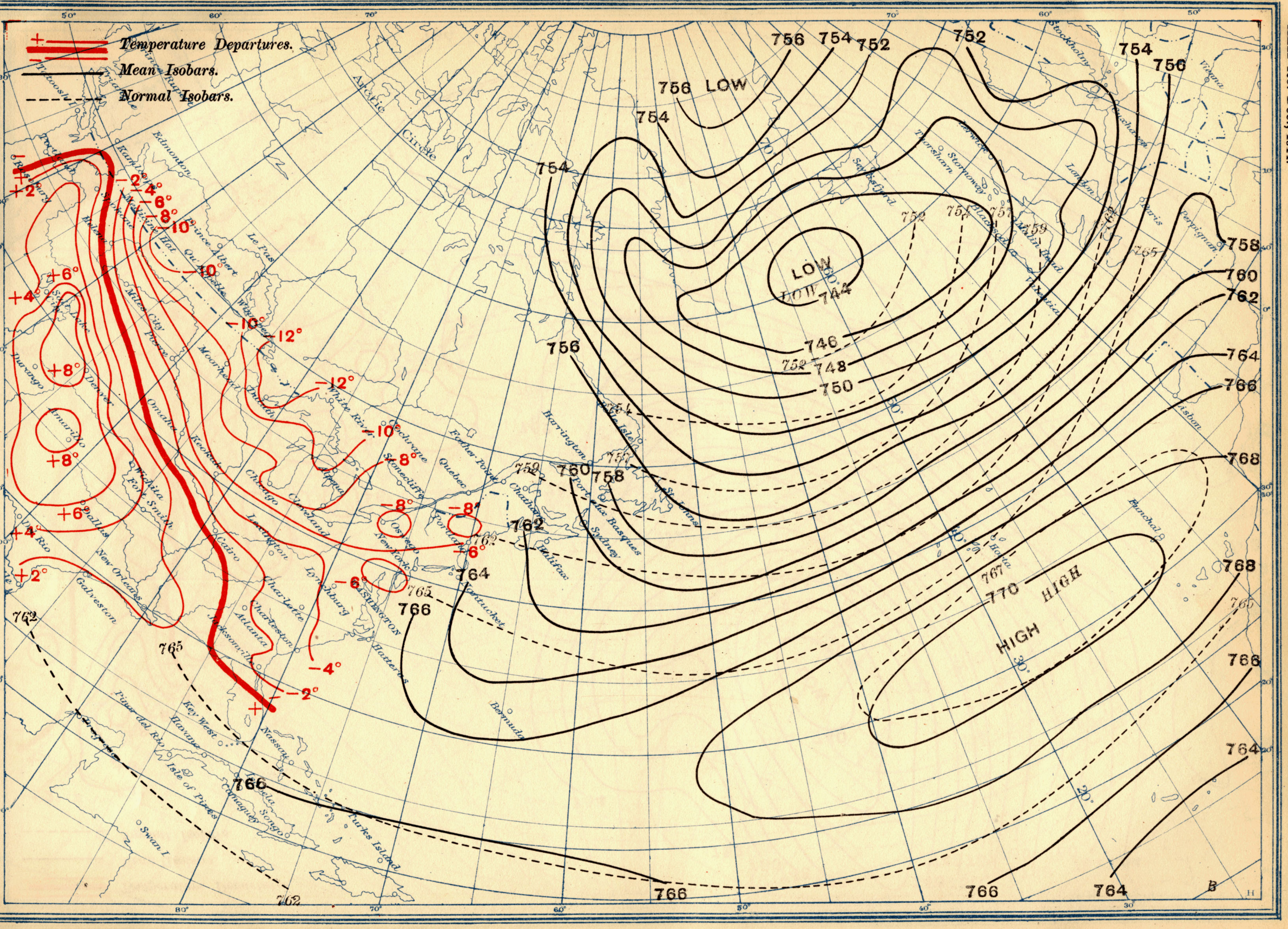


XLII—103. Dec., 1914.

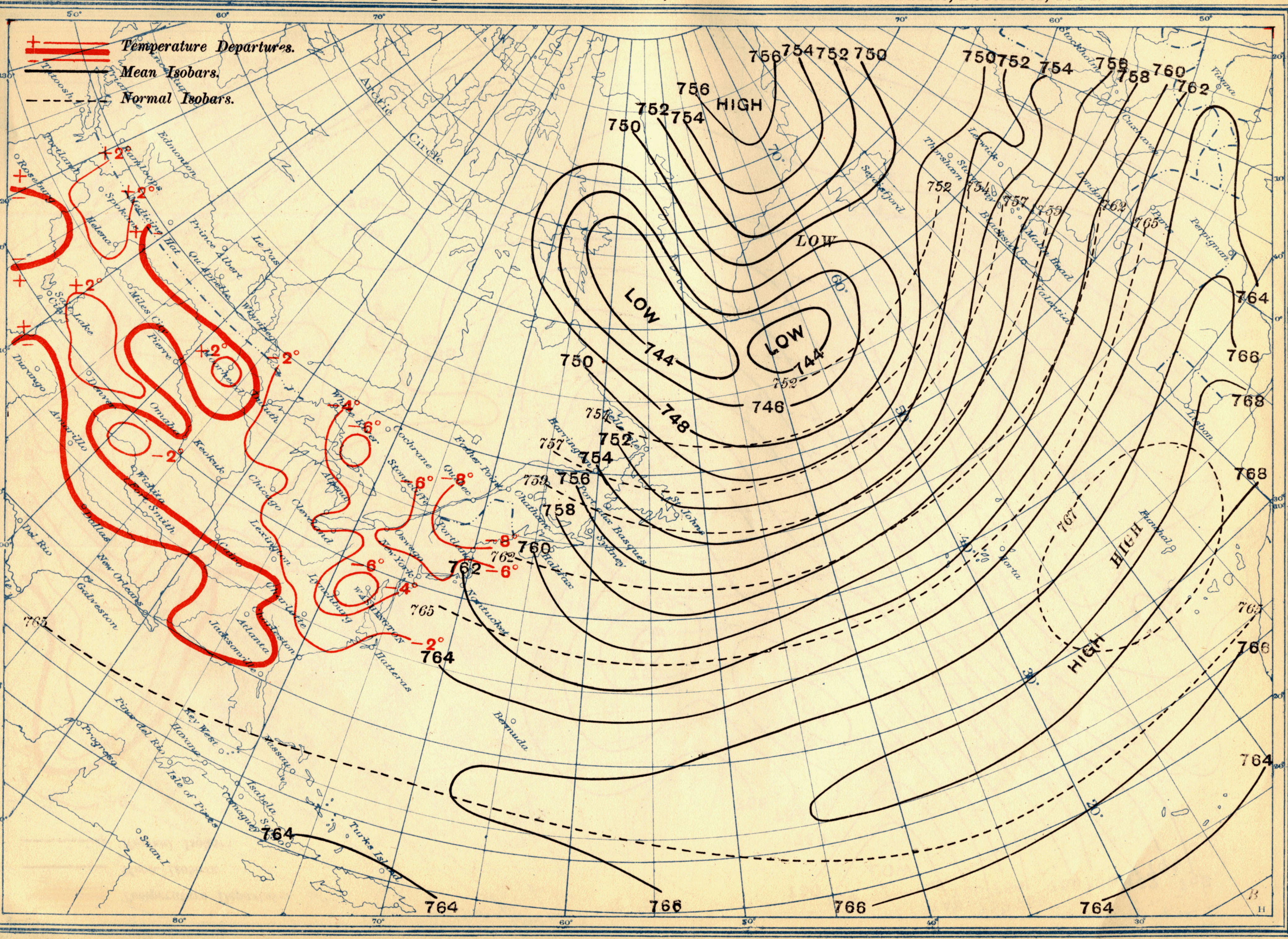
W. J. H. 13.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, January, 1904.



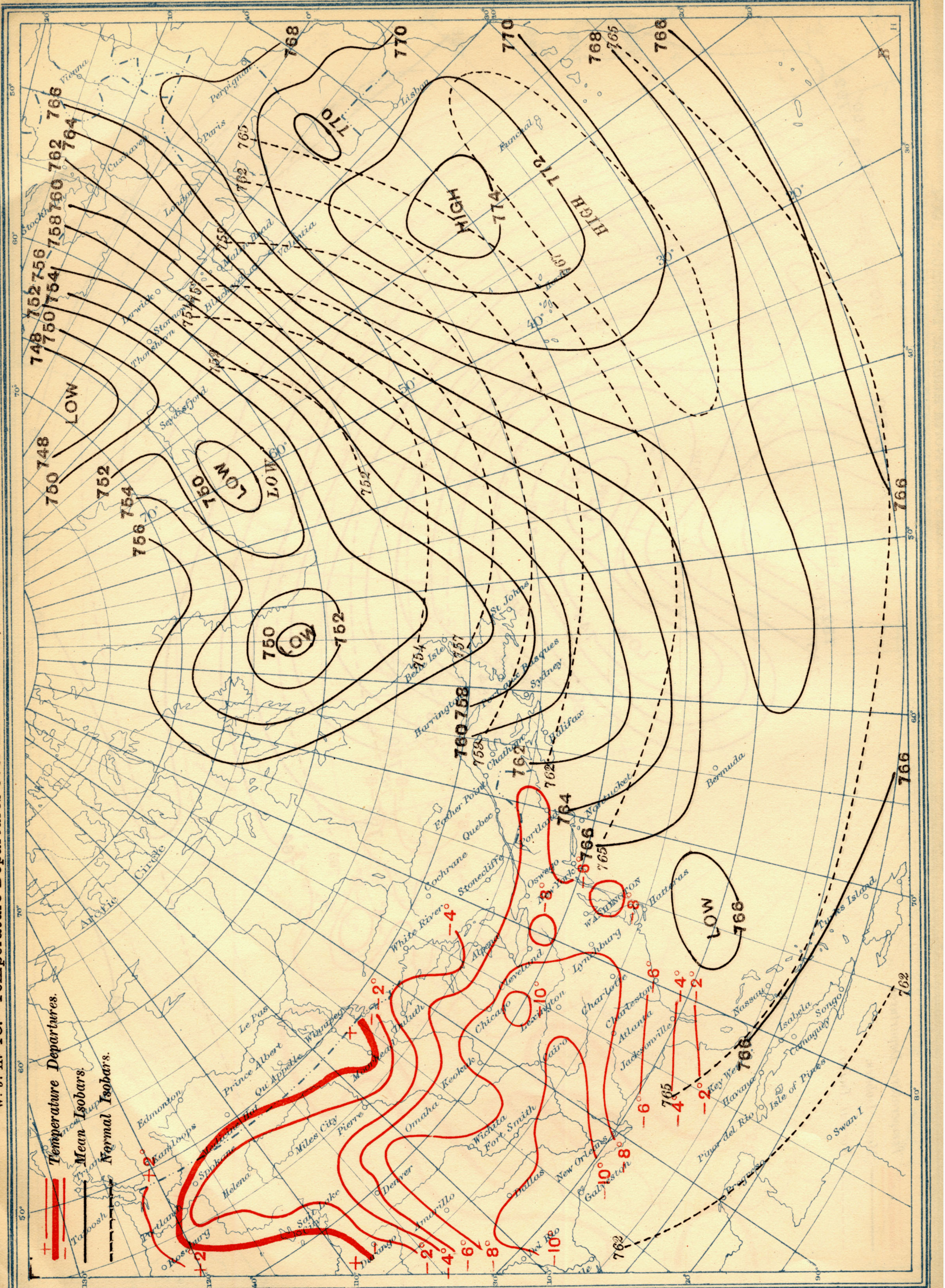
W. J. H. 14.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, February, 1904.



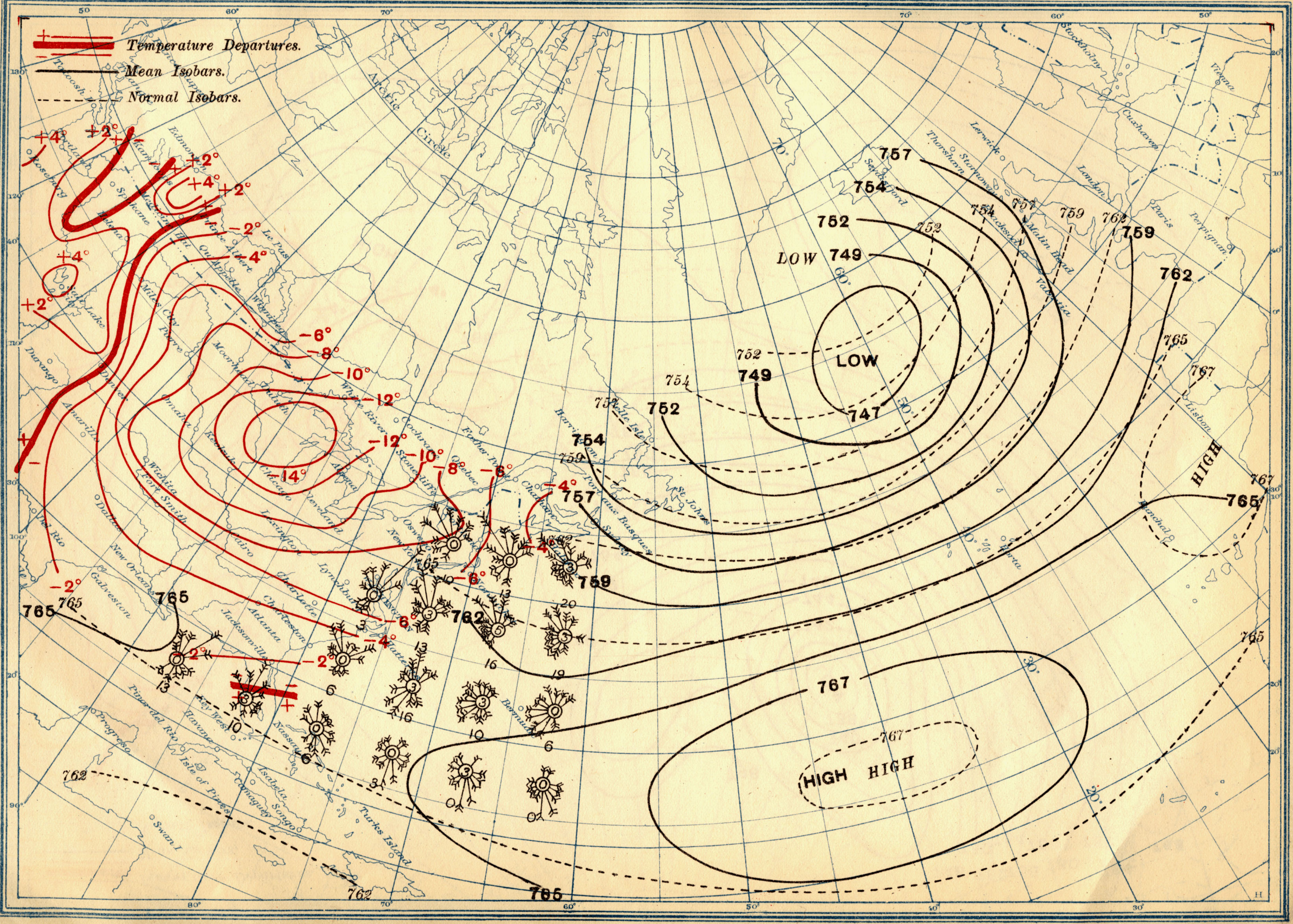
W. J. H. 15.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, December, 1904.



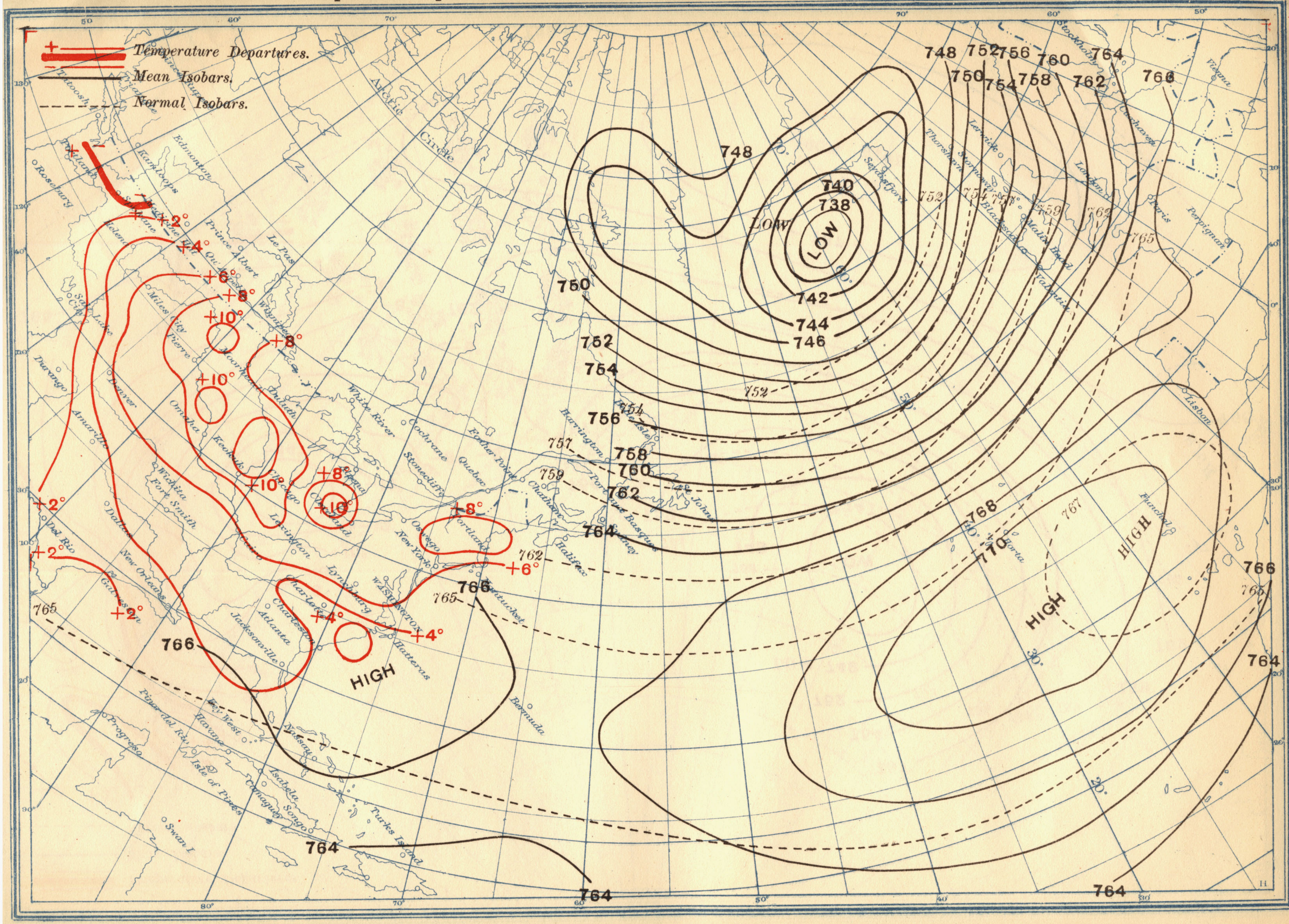
W. J. H. 16.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, February, 1905.



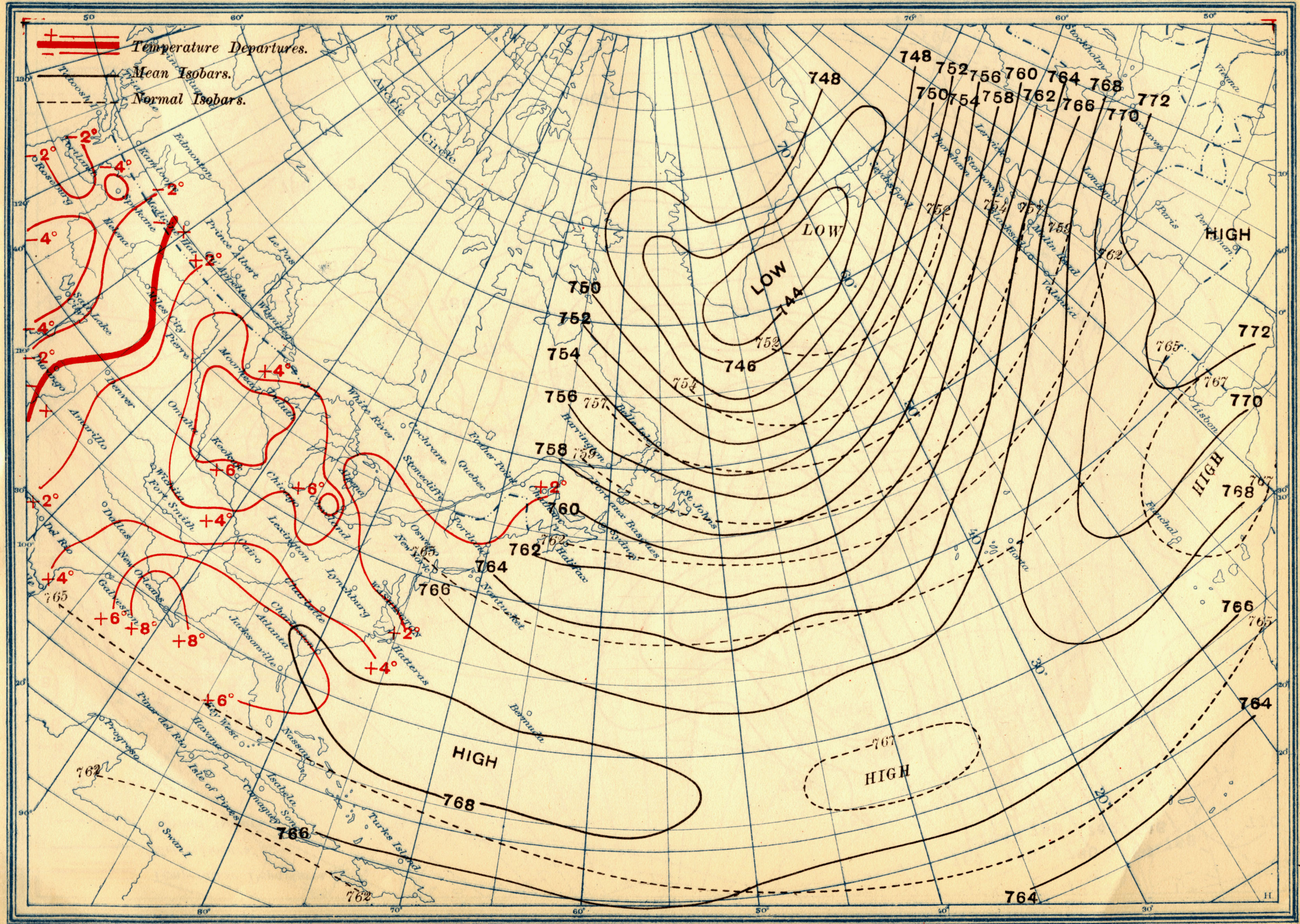
W. J. H. 17.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, January, 1912.

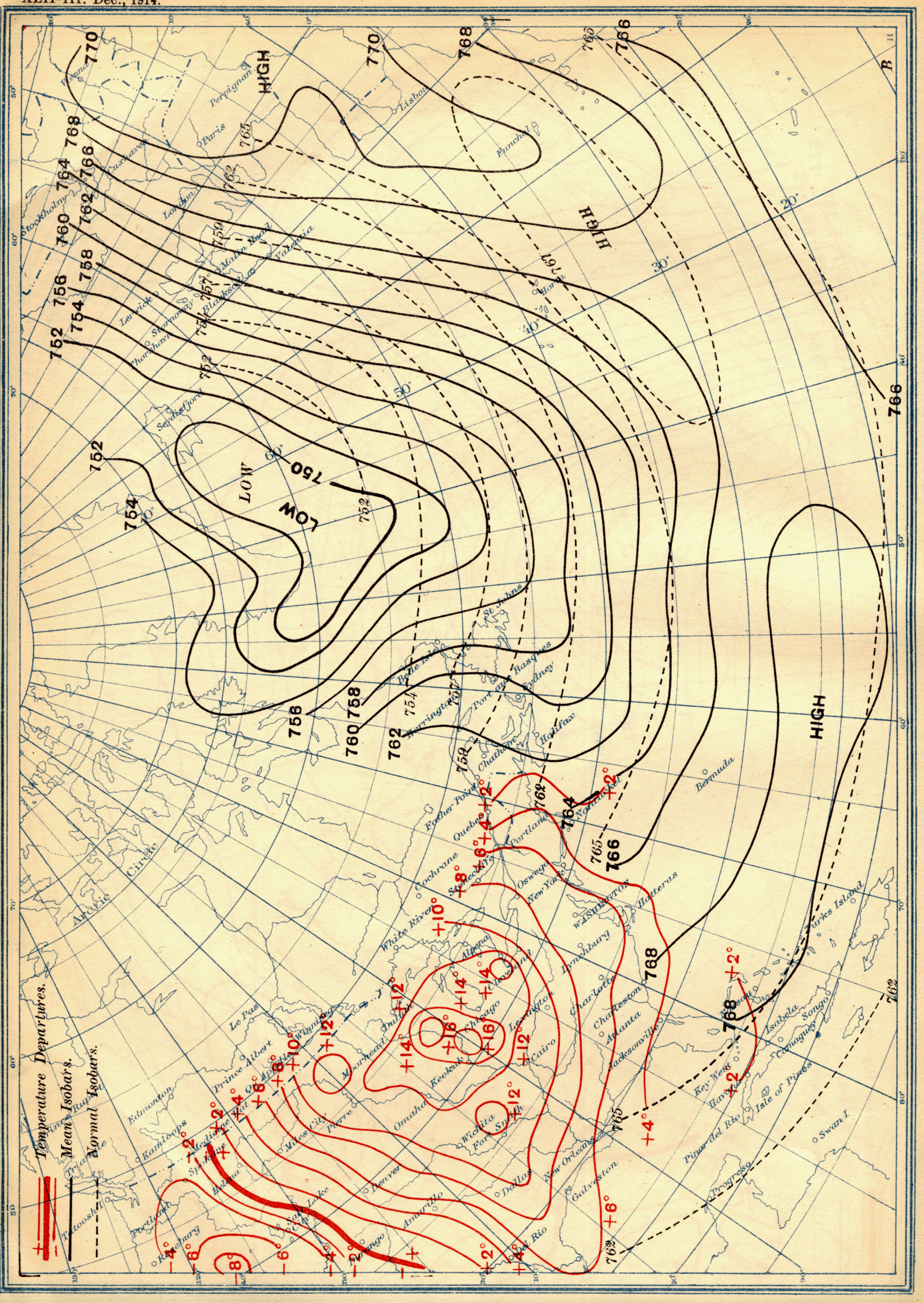


W. J. H. 18.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, December, 1881.



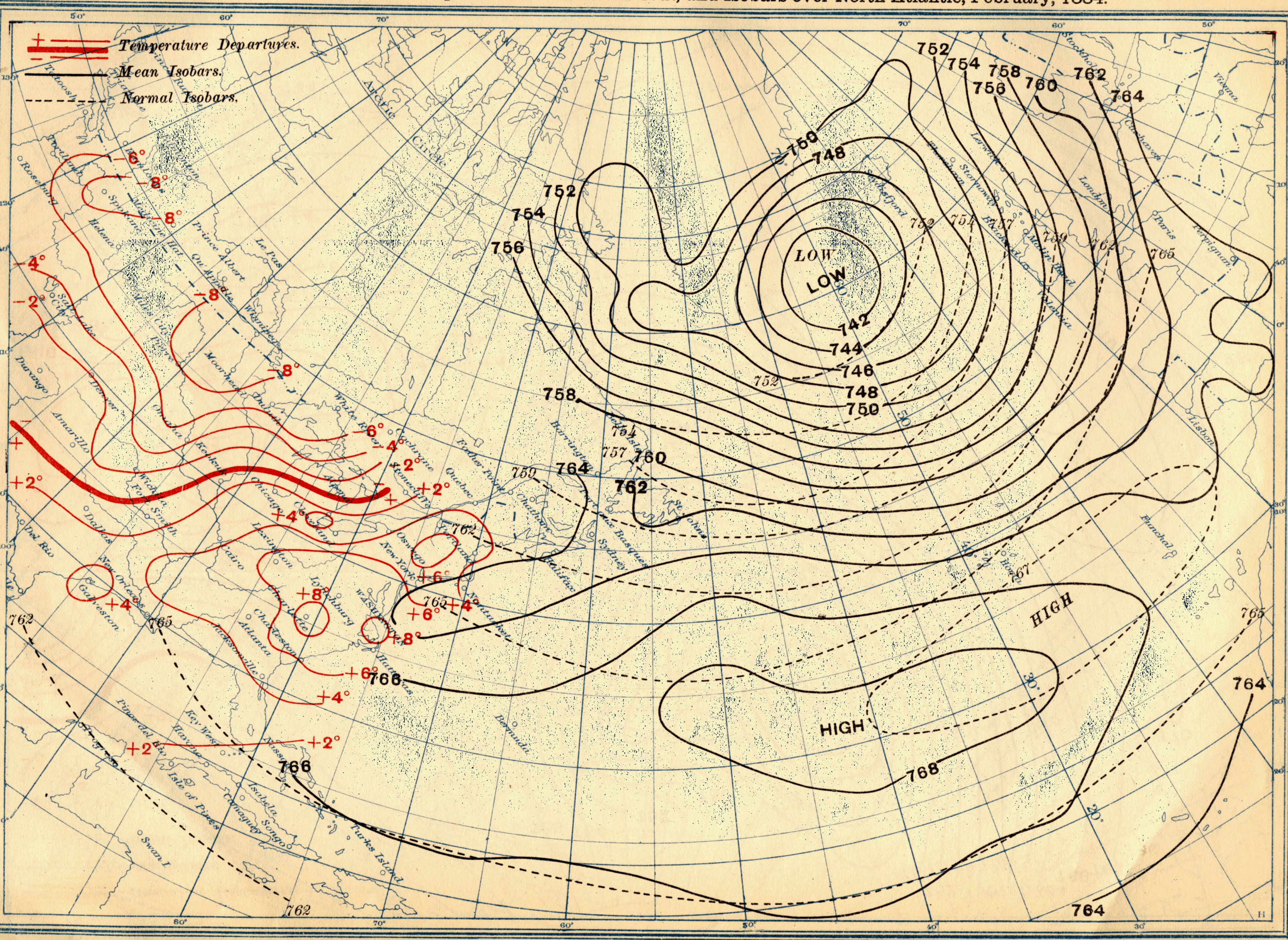
W. J. H. 19.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, January, 1882.



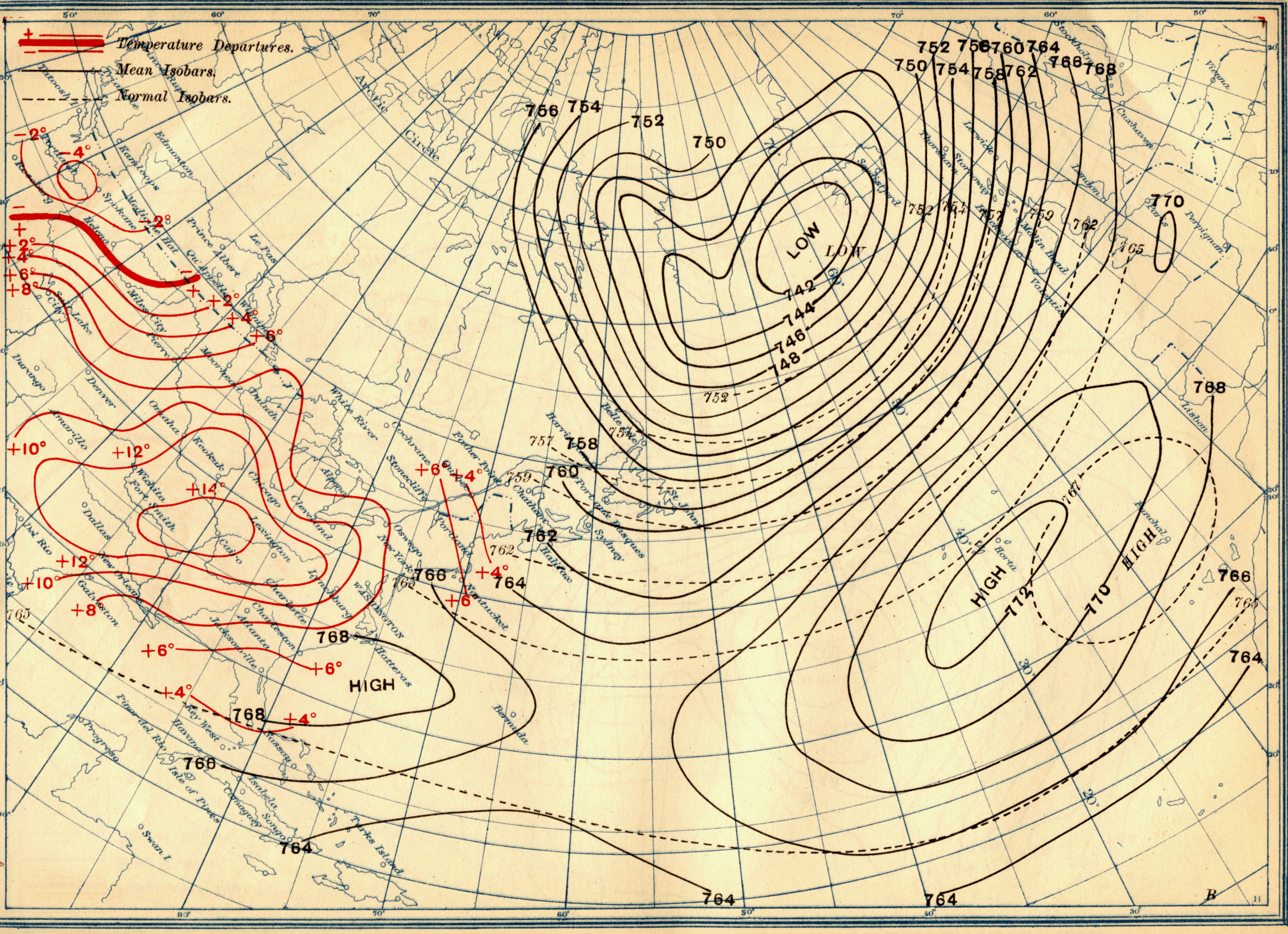


W. J. H. 20.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, February, 1882.

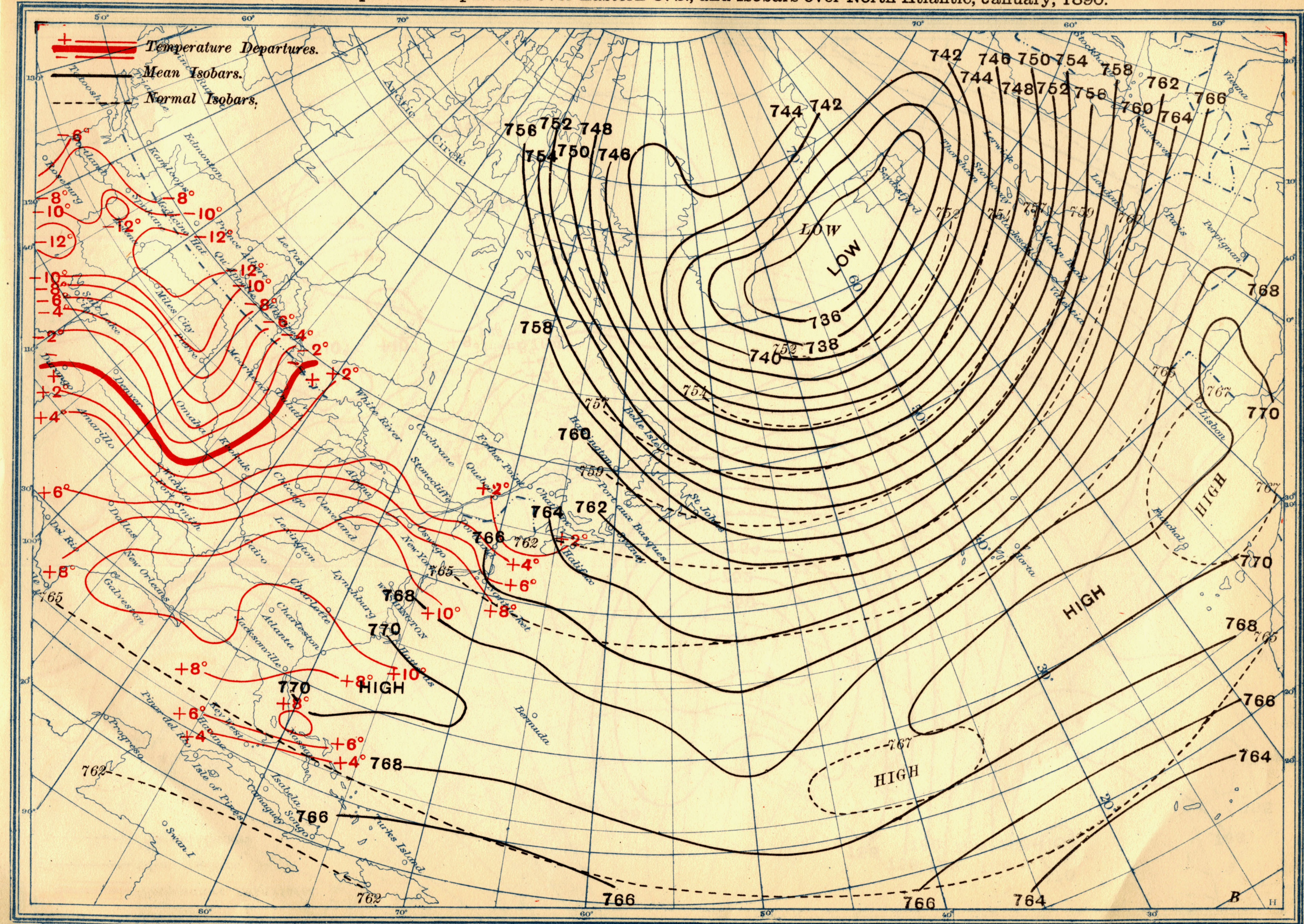
W. J. H. 21.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, February, 1884.



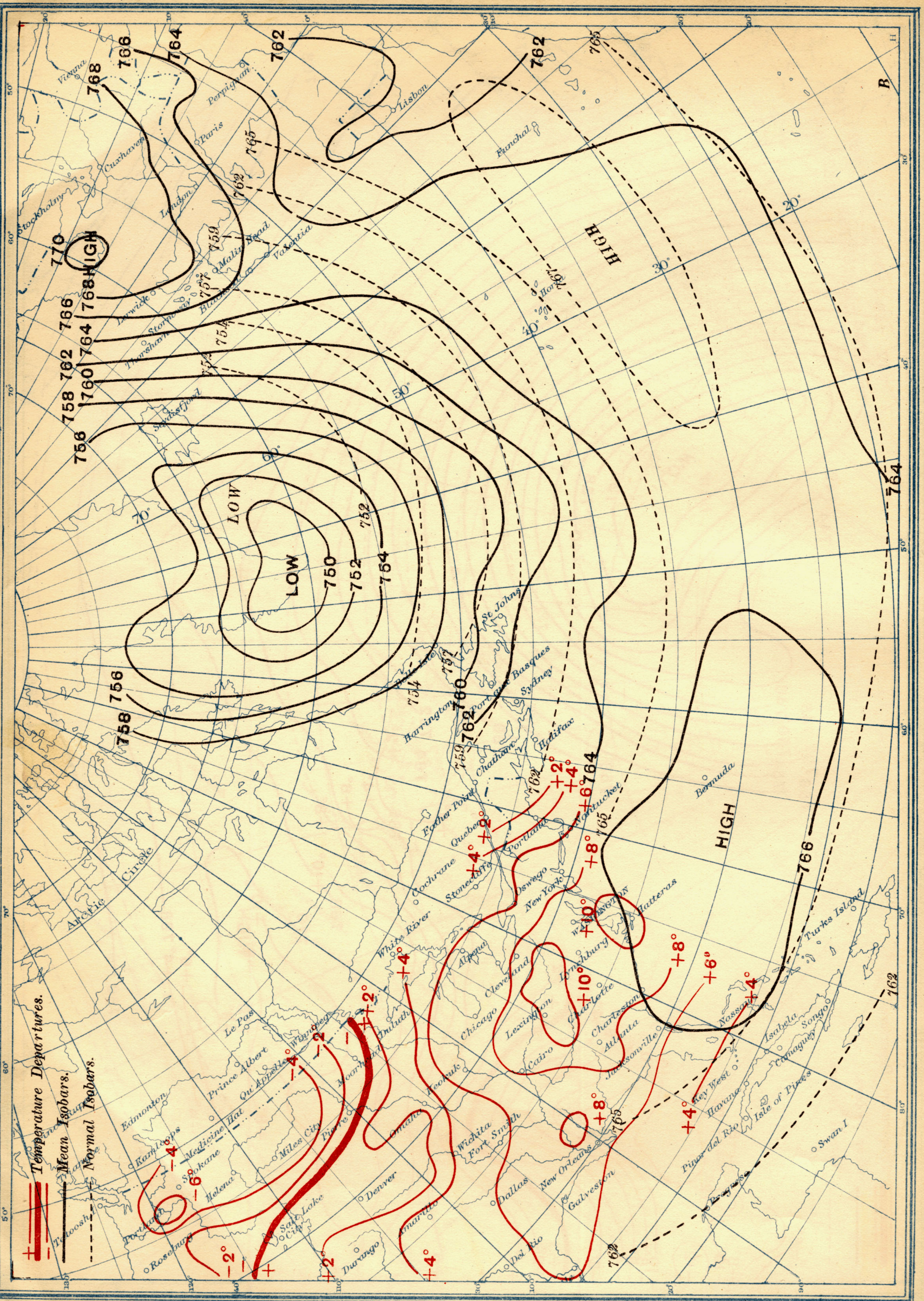
W. J. H. 22.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, December, 1889.



W. J. H. 23.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, January, 1890.

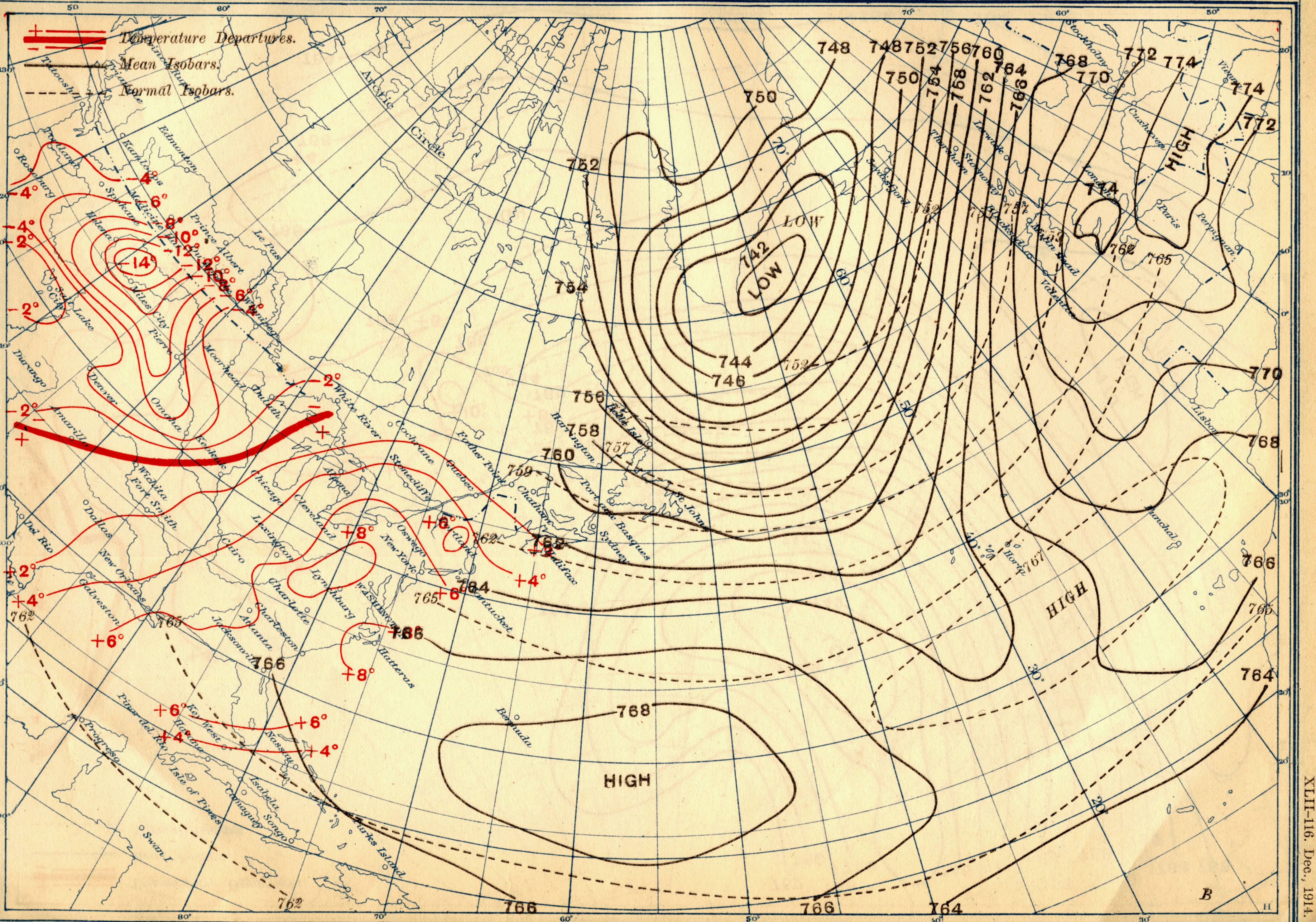


XLII-114. Dec., 1914.

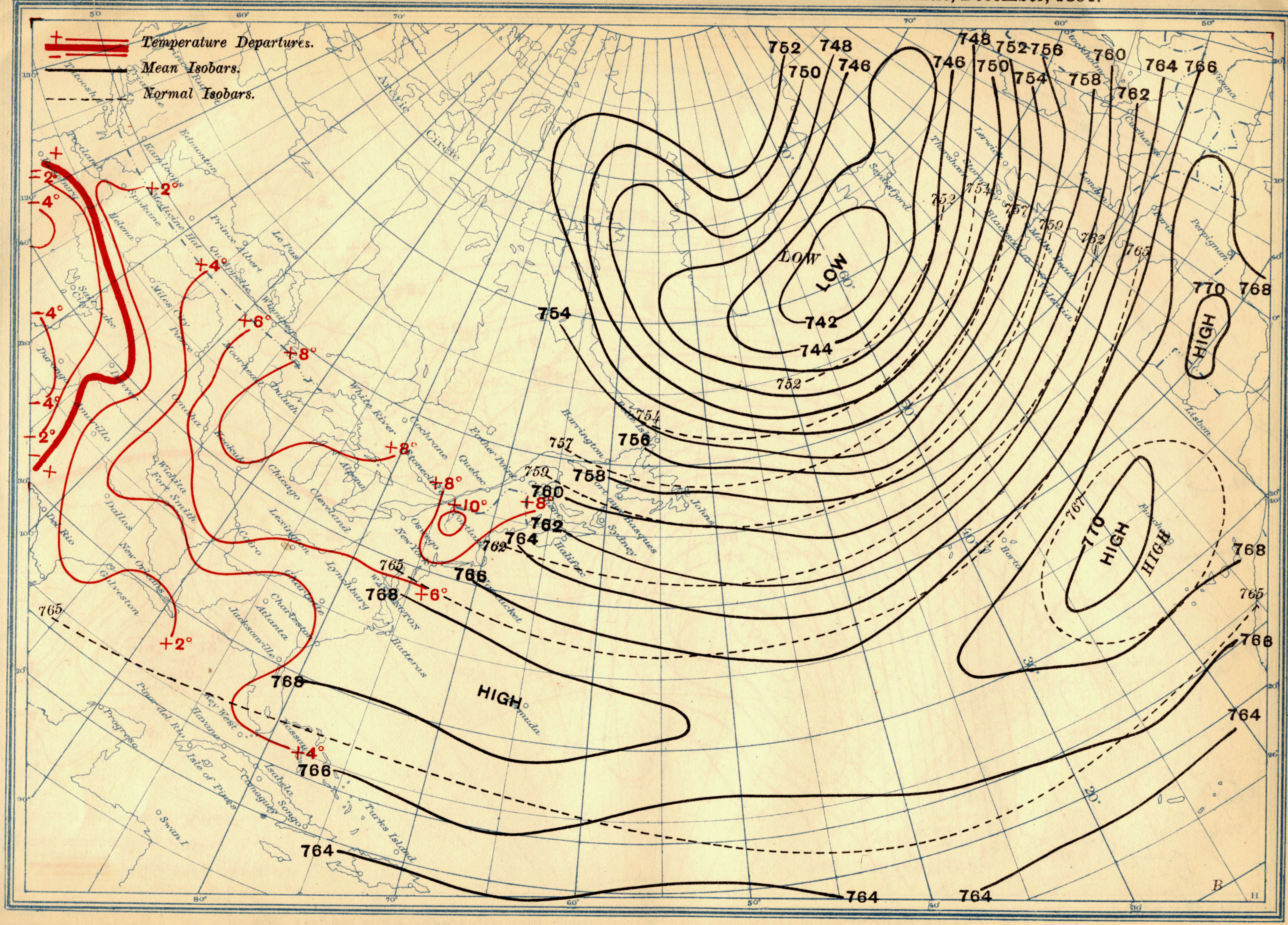


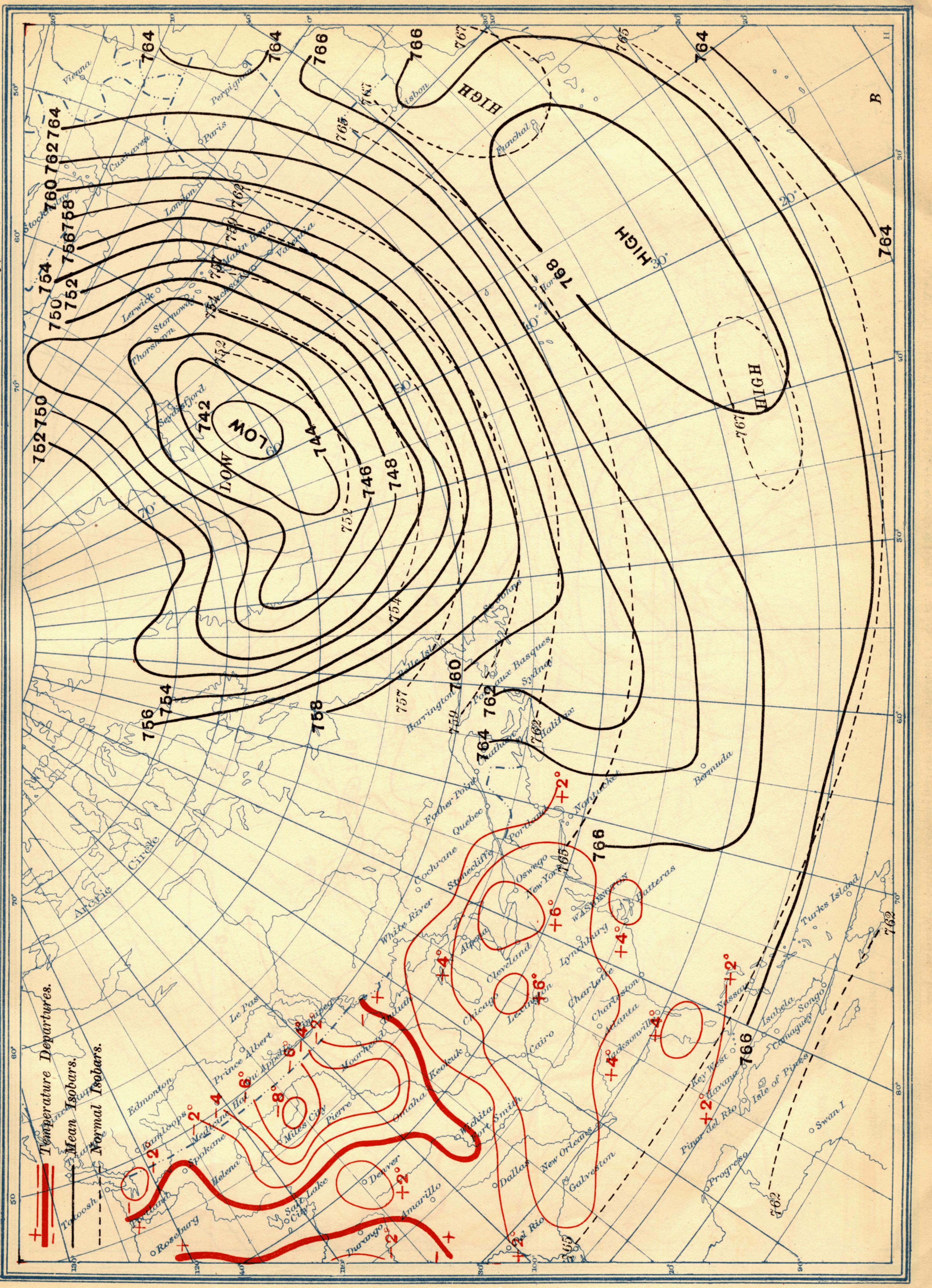
W. J. H. 24.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, February, 1890.

W. J. H. 25.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, February, 1891.



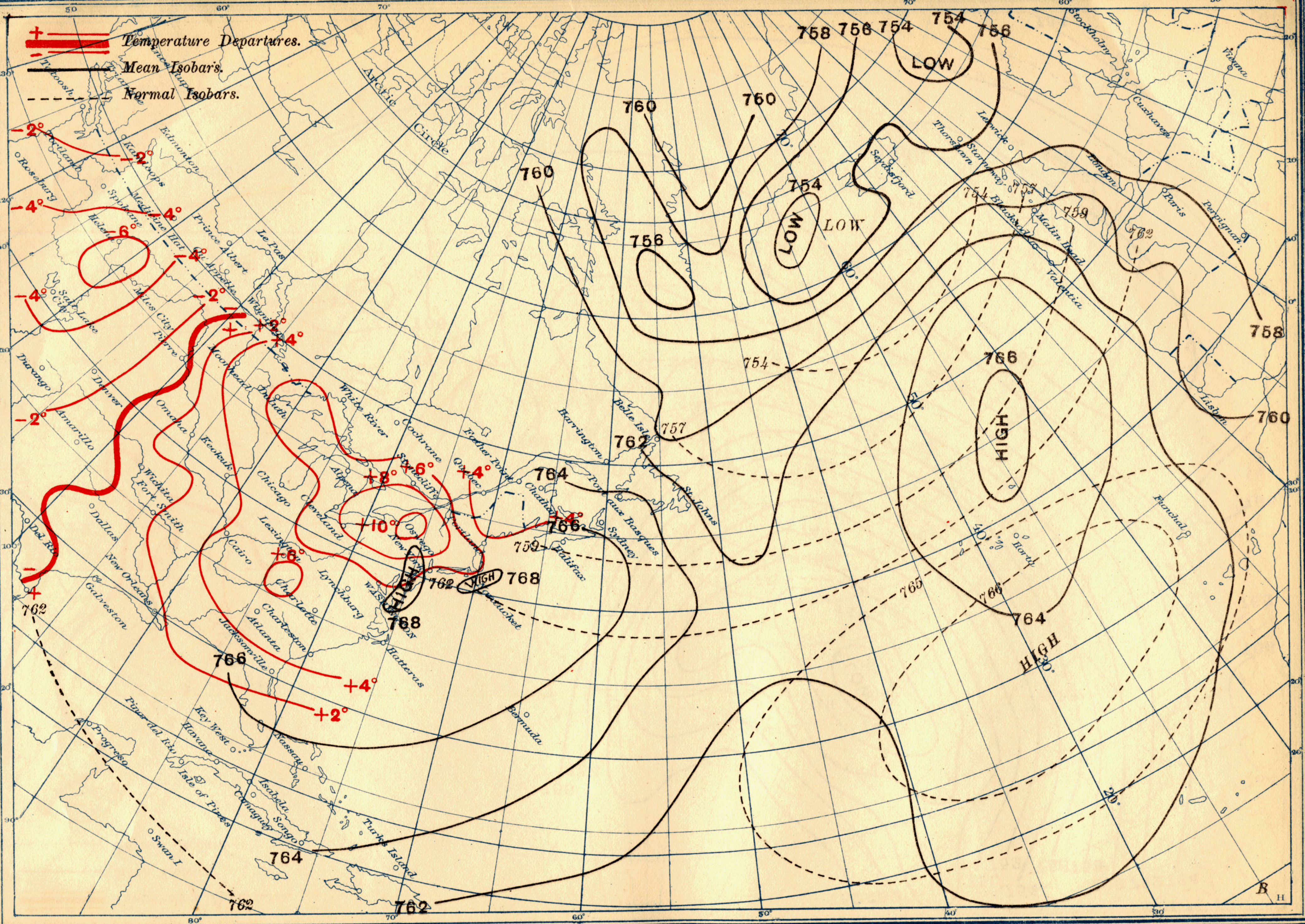
W. J. H. 26.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, December, 1891.



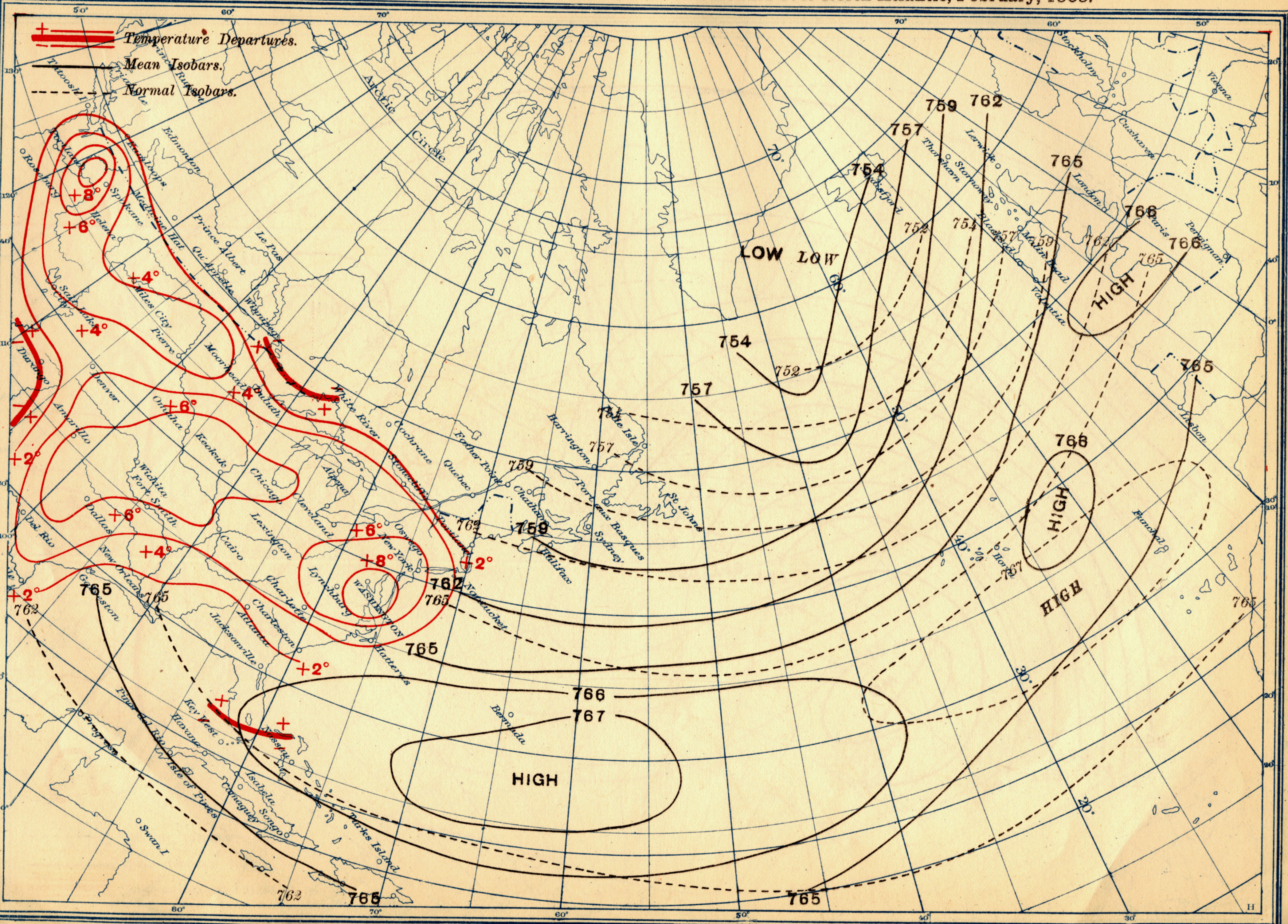


W. J. H. 27.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, January, 1894.

W. J. H. 28.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, March, 1898.

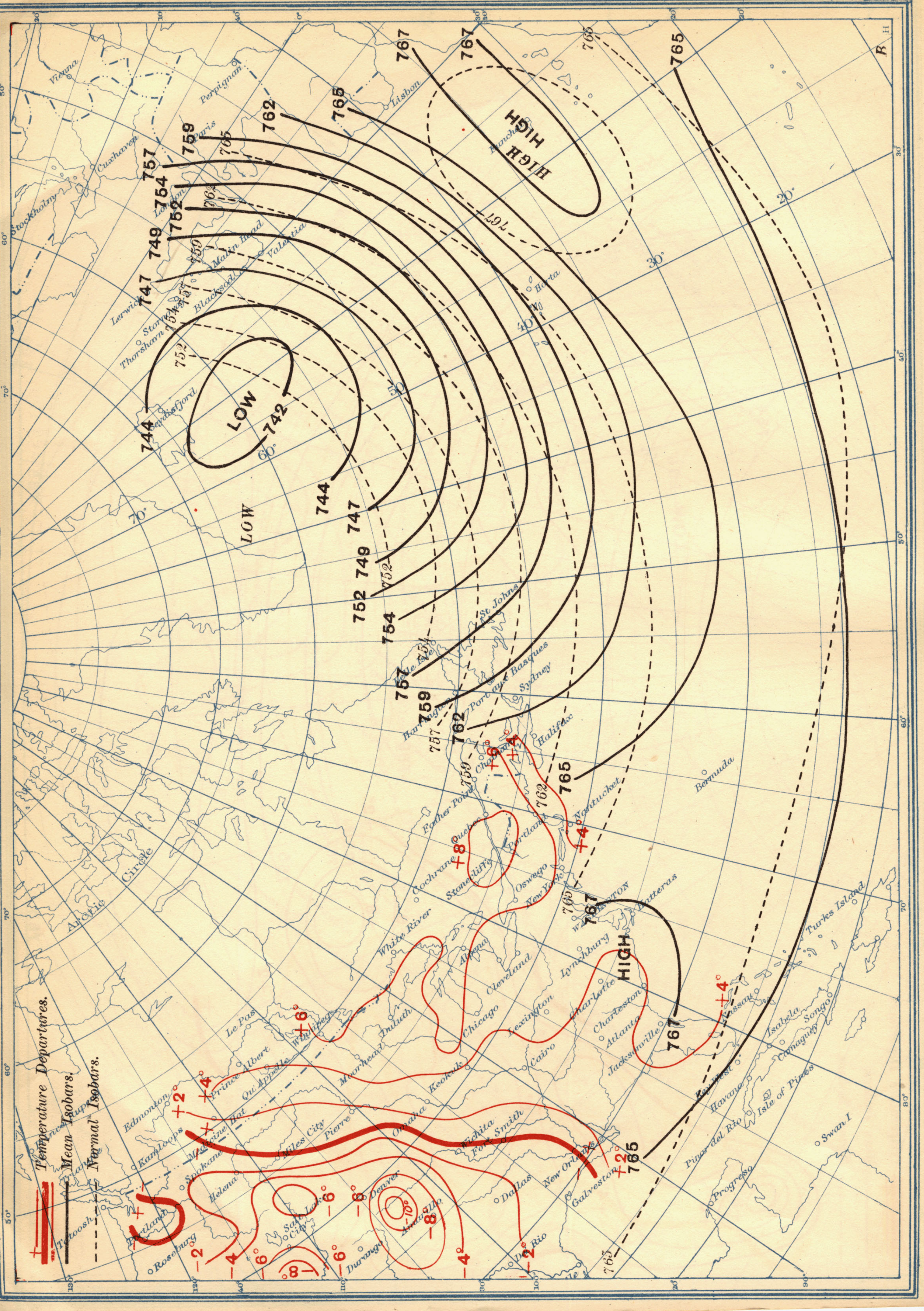


W. J. H. 29.—Temperature Departures over Eastern U. S. and Isobars over North Atlantic, February, 1909.

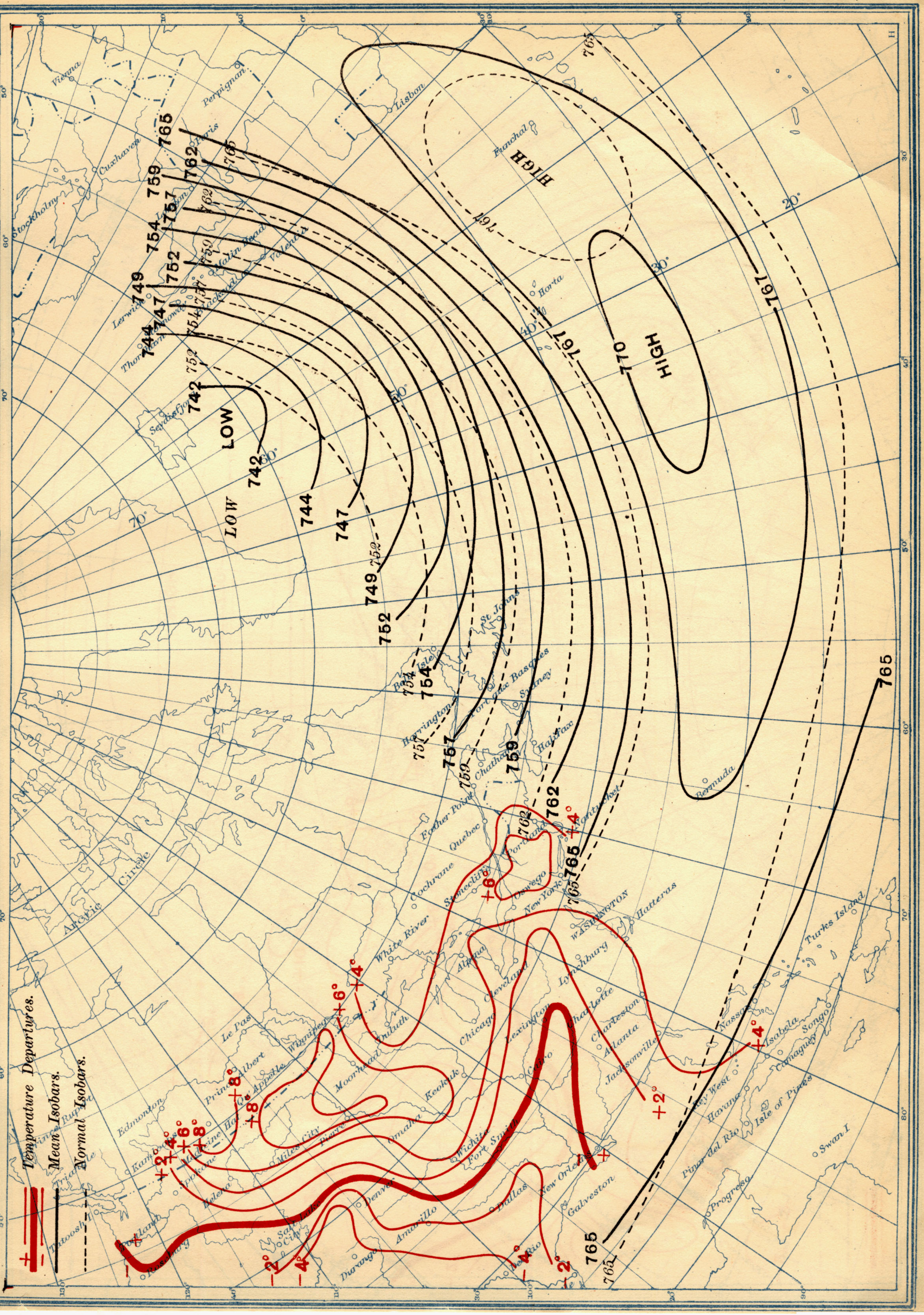


XLII-120. Dec., 1914.

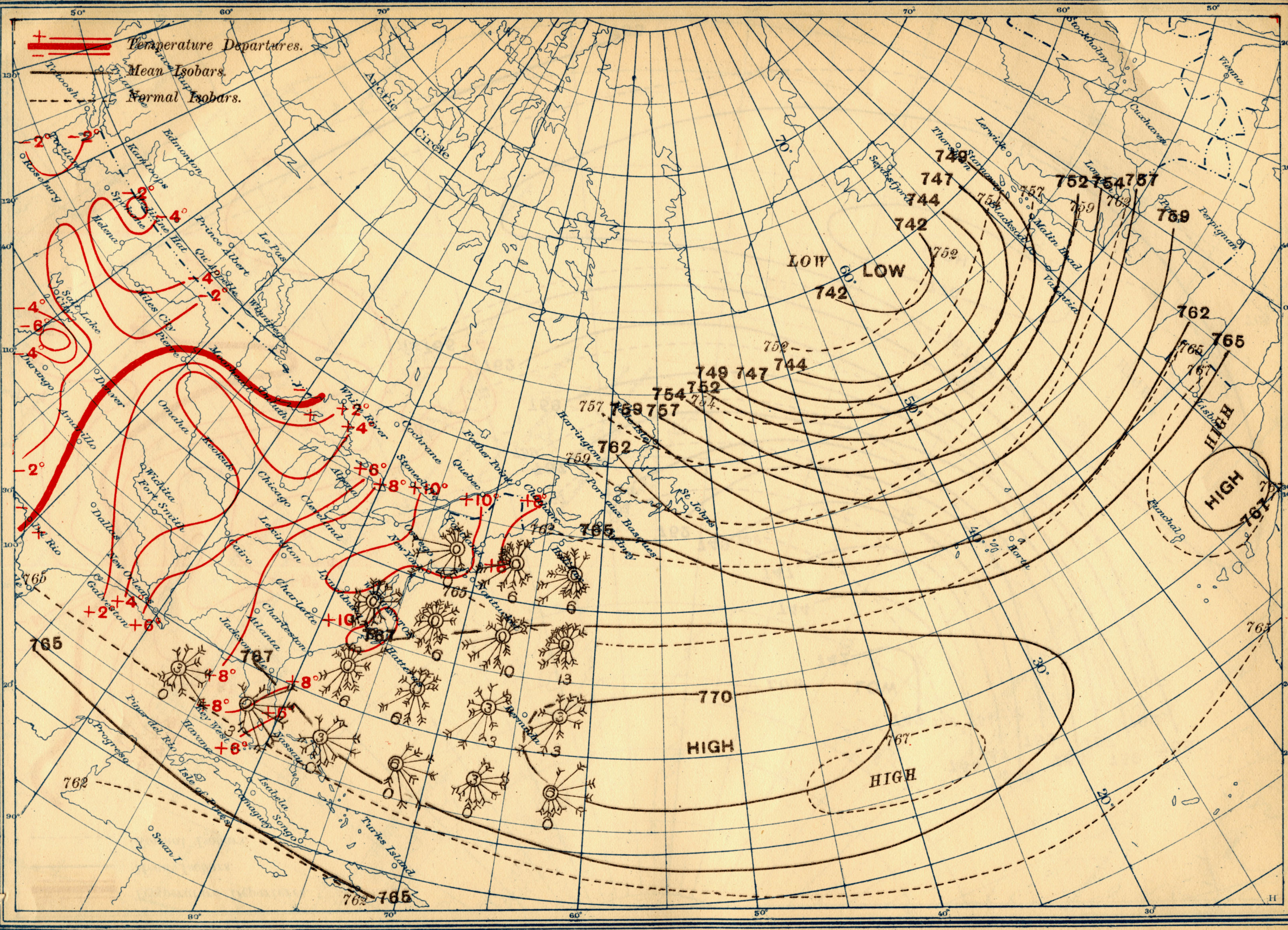
W. J. H. 30.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, December, 1911.



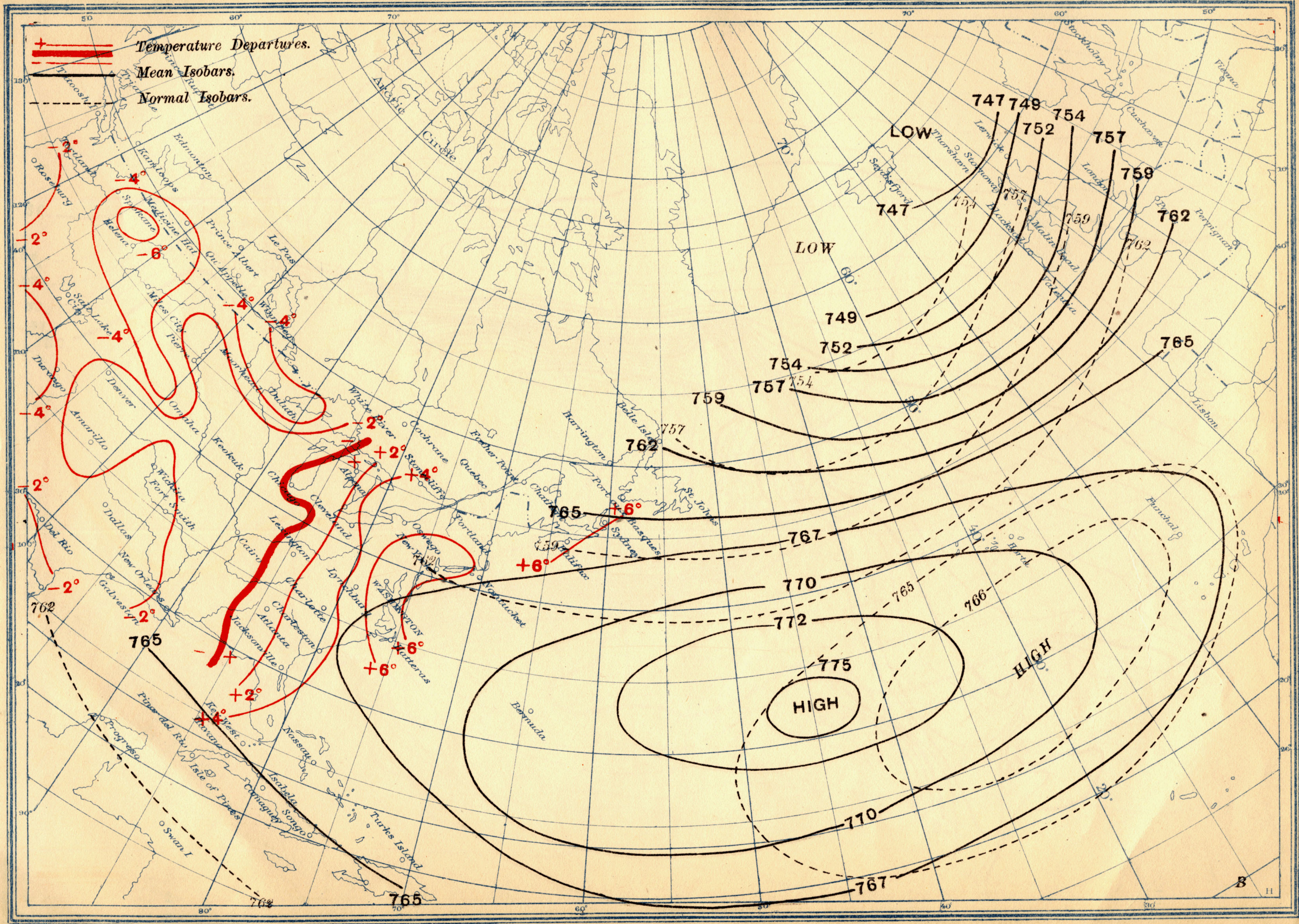
W. J. H. 31.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, December, 1912.

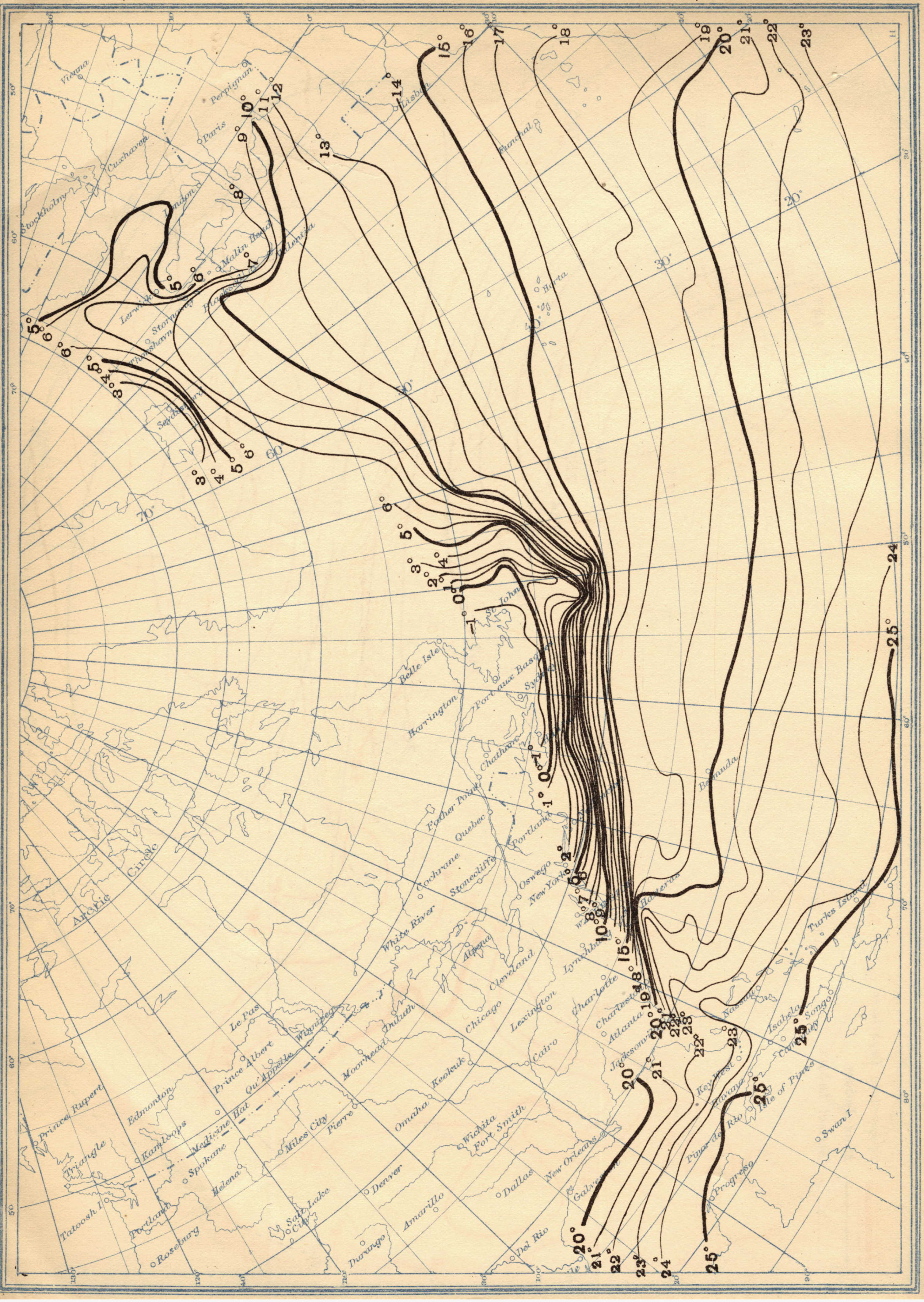


W. J. H. 32.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, January, 1913.



W. J. H. 33.—Temperature Departures over Eastern U. S., and Isobars over North Atlantic, March, 1913.





W. J. H. 34.—Surface Water Temperatures, North Atlantic, February. (After Deutsche Seewarte).

W. J. H. 35.—Surface Water Temperatures, North Atlantic, May. (After Deutsche Seewarte).